4-A
GEOTECHNICAL DATA REPORT FOR PROPOSED ROUTE 9 TREATMENT PLANT SITE

FINAL ENVIRONMENTAL IMPACT STATEMENT

Brightwater Regional Wastewater Treatment System

APPENDICES

King County Brightwater TREATMENT SYSTEM

Final

Appendix 4-A
Geotechnical Data Report for Proposed Route 9 Treatment Plant Site

August 2003

Prepared for King County by
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King County
Department of Natural Resources and Parks
Wastewater Treatment Division

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INTRODUCTION

This draft data report presents the results of our field explorations, laboratory testing, and geologic interpretation for the proposed Brightwater Route 9 Treatment Plant site and for the proposed influent pump station (IPS) boring which was also drilled at the Route 9 site. Our scope of work included drilling six borings for the plant site and one deep boring for the IPS, performing geotechnical and environmental laboratory testing, and interpreting the geology and subsurface conditions.

Our work was conducted in general accordance with our scope of work dated November 2002 and revised on both April 14 and June 10, 2003 via email. A partial notice to proceed was provided by CH2M HILL in a letter dated February 7, 2003. Our subcontract was authorized by CH2M HILL (purchase order 63883) and was received at Shannon & Wilson on May 27, 2003. CH2M HILL authorized the revised services (change notice 28) by email on July 3, 2003.

SITE AND PROJECT DESCRIPTION

The general location of the project site is shown on Figure 1, Vicinity Map. The site is located between SR-9 and SR-522 just north of Woodinville, Washington, and is about eight tenths of a mile long (north-south) and two tenths of a mile wide (east-west). The project area is currently occupied by several businesses such as two auto part yards, a steel reinforcing production yard, an insurance auto auction yard, a utility installation contractor yard, an office building, a soup plant, and several parking lots. The Site and Exploration Plan is shown on Figure 2. This figure includes previous borings by CH2M HILL for the Route 9 site and borings by Nelson-Couvrette & Associates completed for other projects.

To the east of the site, there is a relatively steep hill heading up towards SR-522. To the west, there is a gentle slope down towards Little Bear Creek. In general, the site slopes gently down towards the west, with an overall elevation difference of about 60 feet.

FIELD EXPLORATIONS

Current Borings

To generally identify and characterize the subsurface conditions at the proposed site, both existing boring logs and new field explorations were used. Six new soil borings were drilled and sampled for the proposed plant and one deep boring was cored and sampled for the proposed IPS shaft. The surveyed boring locations are shown on the Site and Exploration Plan, Figure 2. Observation wells were installed in five of the six plant borings. Vibrating wire piezometers (VWP) were installed in four of the six plant borings. Five VWPs were installed in the deep IPS boring.

Several more borings were originally planned for the plant site, but were not completed during this phase of the work. The six plant site borings were drilled to depths of 10 to 110.3 feet. The soil borings were accomplished between April 2 and April 10, 2003. The six soil borings are designated PB-2, PB-4, PB-6, PB-7A, PB-7B, and PB-10. Boring PB-7A was abandoned at 10 feet because the augers could not be kept vertical due to near surface rocks. The IPS boring, designated PB-12, was drilled using sonic core and wireline soil core techniques; it was drilled to a depth of 501 feet between March 27 and April 5, 2003.

The field exploration methodology and procedures used during drilling, coring, and sampling the six plant site borings and one IPS boring are discussed in Attachments A and C, respectively. The plant site exploration logs are presented as Figures A-3 through A-8, in Attachment A. Attachment C includes the IPS boring log as Figure C-3 and the core sample photographs as Figure C-4.

The samples obtained from the six plant site borings were screened for potential contamination using a photoionization detector (PID) as well as visual and olfactory methods. One environmental sample was collected from boring PB-7B. Attachment A includes a discussion of the environmental testing and Attachment E presents the test results. During the first day of sonic coring at boring PB-12, air monitoring and soil screening was completed using a PID; no signs of potential contamination were observed. Thus, the use of a PID was terminated after the first day of sonic coring.

Previous Field Explorations

Several previous borings were also used in our study. The SB-series (CH2M HILL and Shannon and Wilson, 2002) and Nelson-Couvrette & Associates (B-x-1999) boring logs are presented as Figures A-9 through A-18 in Attachment A. Their locations are shown on Figure 2. The locations of the previous explorations completed by Nelson-Couvrette & Associates were estimated by CH2M HILL; the previous SB-series boring locations were surveyed.

LABORATORY TESTING

Geotechnical Laboratory Testing

To aid in the team's interpretive report, laboratory tests were performed on selected samples retrieved from the borings to determine basic index and engineering properties of the soils encountered. The geotechnical laboratory testing was performed in the Shannon & Wilson, Inc. laboratory in Seattle, Washington, and included visual classification, water content determinations, Atterberg Limits determinations, grain-size distributions, combined analyses, percent passing the No. 200 sieve, and hydraulic conductivity testing. Laboratory testing was performed in general accordance with the American Society for Testing and Materials (ASTM) standard test procedures. Descriptions of the test procedures and summaries of the test results for the plant site and IPS boring are presented in Attachments B and D, respectively.

Environmental Laboratory Testing

As mentioned above, one environmental soil sample (PB-7B, sample S-1) was collected and tested for Northwest Total Petroleum Hydrocarbon (NWTPH-HCID). The test results indicated that hydrocarbons were non-detect. The test results are presented in Attachment E. In our opinion, the odor noted in the sample was probably organics.

Radiocarbon Dating

Two samples containing some organics were submitted to Beta Analytic Inc. of Miami, Florida for radiocarbon dating. These tests were performed to better clarify the geologic interpretation at the site. The Beta Analytic Inc. test results are included in Attachment D.

SUBSURFACE CONDITIONS

The geologic and subsurface conditions were inferred from the material and information obtained from the current and previous explorations and from geologic maps of the area. The following sections include a description of the proposed plant site geology, and the soil and groundwater conditions encountered in the borings.

Geologic Unit Designations

The geologic units used for the proposed Brightwater SR-9 Treatment Plant project are based on basic divisions of geologic time and on geologic processes. The grouping of soils in this fashion was used for this project because the geotechnical properties of the soils are largely controlled by (1) grain size and sorting, which are functions of depositional processes, (2) consolidation history and structural discontinuities, which are functions of the geologic history, and (3) permeability of the units. Understanding the geologic history and depositional processes also allows for better interpolation of the unit boundaries between borings.

The geologic unit designations that we have applied to the soils encountered across the proposed treatment plant site represent our interpretation of the grouping of complex sediments and soil types. The boring logs present our interpretation of the geologic layering.

Nomenclature

The soils encountered at the site were grouped into different units based on geologic criteria, such as grain size, color, presence of organics and shell fragments, fabric, relative density/consistency, and presence of artificial debris. Major delineations were based on geologic age. Further differentiation of the sediments was based on geologic process or depositional environment. Each geologic unit has a three- to four- letter abbreviation where each letter signifies some aspect of geologic age, depositional environment or geologic process.

The Pleistocene geologic record in the Puget Lowland consists of alternating glacial and interglacial climatic intervals. Prior to the last (Vashon) glaciation, there were several interglacial and glacial episodes, which are difficult to distinguish from other interglacial and glacial episodes. Radiocarbon age dating of organic material was used in places for determining the age of sediments deposited during interglacial episodes; these radiocarbon age dating results are attached. However, the useful range for radiocarbon dating extends back only about 40,000 to 50,000 years before the present, which is in the middle of the interglacial episode just prior to the Vashon Stade of Fraser Glaciation. Therefore, all sediments older than Vashon age were termed pre-Fraser.

Depositional environments and processes varied during interglacial and glacial times, so pre-Fraser deposits were grouped into glacial and nonglacial units. For clarification, the term "interglacial" refers to the interval of time between glaciations, while the term "nonglacial" refers to processes or sediments deposited during interglacial episodes. While the nonglacial sediments deposited during interglacial periods prior to the Vashon Stade were not glacially consolidated initially, they were overridden by ice during subsequent glaciations, and thus are typically very dense and hard. Sediments deposited since the Vashon Stade are Holocene deposits. Holocene sediments are also nonglacial, but are not glacially consolidated.

A discussion of each of the geologic units encountered during the subsurface exploration program or identified on exploration logs completed by others across or near the plant site is presented below, from youngest to oldest. The discussion of each unit below focuses on depositional processes and the general geologic characteristics resulting from those processes that were useful for designating a particular geologic unit, including permeability. While any of the deposits may contains cobbles and boulders, certain of these deposits are likely to contain them; they are identified in their descriptions.

Geologic Unit Descriptions

Holocene Units

Holocene sediments have been deposited since the disappearance of glacial ice in the central Puget Lowland, approximately 13,500 years ago. The sediments were deposited by nonglacial geologic processes that are largely active today, such as erosion, landsliding, stream action, and human activities such as excavating and filling. Because these sediments have not been glacially overridden, they are generally normally consolidated or slightly overconsolidated, and are very loose to dense or soft to very stiff. Alluvium in Little Bear Creek and landslide debris on the steep slopes to the east of the property are located adjacent to the subject property. The only Holocene deposit recognized on the property is fill.

Fill (f) is soil placed by humans in an engineered and nonengineered manner. Fill is composed of various materials, including soil, rock fragments, and debris. It can be dense, stiff, and unyielding if engineered, and is very loose to dense where non-engineered on this site. Its permeability is highly variable.

Vashon Units

These sediments were deposited between about 13,500 and 15,000 years ago by the last glacial ice sheet (the Vashon Stade of the Fraser Glaciation) to occupy the Puget Lowland. However, not all of these sediments were glacially overridden. The recessional deposits were laid down as the ice receded or melted, so they did not receive the overconsolidating pressure of the glacial ice.

Normally Consolidated Vashon Sediments

These sediments, though deposited by glacial processes during the last (Vashon) glacial episode, were deposited during the retreat or wastage of the ice sheet and were not overridden by the Vashon Stade ice sheet. Consequently, they are normally consolidated and are very loose to dense or soft to very stiff.

Most of the recessional deposits, which occur in the upper 10 to 30 feet of the site, are outwash, but there are pockets and layers of lacustrine and ice-contact deposits scattered around the site.

Vashon Recessional Outwash [Qvro].

These glaciofluvial outwash sediments were deposited by meltwater streams flowing from the melting ice front as the glacier retreated from and melted in the Puget Lowland. This unit is generally composed of loose to very dense, trace silt to silty sand or sand and gravel, and contains lenses of clay and silt. It has a relatively high permeability. This geologic unit is denoted by the abbreviation Qvrf in some other Brightwater documents and the University of Washington Seattle Area Geologic Mapping Project.

Vashon Recessional Lacustrine Deposits [Qvrl].

These glaciolacustrine sediments formed from the settlement of fine-grained suspended sediments in quiet water in local depressions as the glacial ice retreated from and melted in the Puget Lowland. This unit is commonly composed of very soft to medium stiff, fine sand, silt, and clay with scattered organics, but was found to be very stiff at this site. It generally has a low permeability, although locally the permeability can be moderate.

Vashon Ice-Contact Deposits [Qvi].

Soils of this unit were deposited by one of several depositional processes that take place along the margins of glacial ice, and they can have quite variable characteristics. These soils are commonly composed of stratified or irregular bodies of a heterogeneous mixture of gravel, sand, silt, and clay. These sediments are commonly reworked or modified through sediment slumping or stream action after initial deposition. They range from very loose to very dense, depending on the grain-size characteristics, particularly the gravel content. The permeability is highly variable.

Glacially Overconsolidated Vashon Sediments

These sediments were deposited by Vashon glacial processes and were overridden by the advancing glacial ice after deposition. These sediments are generally dense to very dense, or very stiff to hard.

Vashon Till [Qvt].

This unit was deposited as lodgment till at the base of the advancing Vashon Stade glacial ice and is glacially compacted. This unit is generally a non-clayey diamict composed of a heterogeneous mixture of silt, sand, and gravel with non-plastic to low plasticity fines. It is sometimes referred to as “hardpan” due to its very dense nature and a concrete-like appearance. It has relatively low permeability.

Till-Like Deposits [Qvd].

These till-like sediments are nonsorted or poorly sorted granular deposits exhibiting a wide range of grain sizes (a diamicton), and are generally intermediate between till and outwash. They may have been reworked by subglacial streams flowing in channels and pools directly beneath the ice. They are comprised of very dense, silty sand and sandy silt, with varying percentages of gravel and scattered traces of clay. The permeability of the till-like deposit is low to moderate, but can locally be high.

Vashon Advance Outwash [Qva].

These glaciofluvial sediments were deposited in front of the advancing glacial ice as the Vashon glacier advanced through the Puget Lowland. This unit is generally composed of very dense, clean to silty sand, gravelly sand or sandy gravel. It has relatively high permeability.

Glaciolacustrine Deposits [Qvlc].

These soils are the result of deposition of suspended sediments in quiet water in proglacial lakes in the Puget Lowland. The unit is composed of hard, clayey silt and silty clay with seams of fine sand and cohesionless silt. This unit can be thinly laminated in places, or massive and contain scattered, fine organic debris at the base of the unit, where it is gradational with an underlying nonglacial deposit. This unit is locally known in the Seattle area as Lawton Clay. Glaciolacustrine deposits have a low permeability vertically, but can have moderate permeability horizontally along sandy layers or lenses.

Pre-Vashon Units

Pre-Fraser Nonglacial Units

During the interglacial intervals between the six or more glacial events thought to have occurred in the Puget Lowland during the Pleistocene Epoch, nonglacial processes similar to present-day geological processes were active. These sediments commonly contain wood fragments, peat, or fine organic material. Because these sediments have been overridden by glacial ice one or more times, they are glacially overconsolidated.

Fluvial Deposits [Qpnf].

This unit is comprised of alluvial sediments deposited by rivers and streams. Due to the relatively high energy involved in its depositional environment, it is medium to coarse grained. It is comprised of clean to silty, sandy gravel to gravelly sand and may contain scattered to abundant organic fragments. Nonglacial fluvial soils deposited during the interglacial time just prior to the Vashon Stade make up part of what is called the Olympia Formation. It has a very high to high permeability due to its coarse and clean nature.

Lacustrine Deposits [Qpnl].

These fine-grained sediments were deposited in quiet water in large and small depressions. The unit is composed of stratified clay, silt and fine sand, and contain scattered to abundant fine, organic fragments. Nonglacial lacustrine soils deposited in the interglacial time just prior to the Vashon Stade make up part of what is called the Olympia Formation. It has a very low to low permeability in a vertical direction, but can be moderately permeable horizontally, due to sand layers and lenses.

Pre-Fraser Glacial Units

Six or more glacial episodes may have occurred in the Puget Lowland prior to glaciation during the Vashon Stade. Similar geologic processes and the deposition of similar materials may have occurred during each glaciation. Because these sediments have been overridden one or more times by glacial ice, they are overconsolidated.

Outwash [Qpgo].

This unit is comprised of glaciofluvial sediment deposited as the glacial ice advanced or retreated through the Puget Lowland. Due to the high energy involved in its depositional environment, it is medium to coarse grained. It is comprised of clean to slightly silty, sandy gravel and gravelly sand. It also commonly contains cobbles and boulders. It has a very high to high permeability due to its coarse and clean nature, but is moderate locally.

Glaciolacustrine Deposits [Qpgl].

These deposits are the result of the deposition of suspended sediments in proglacial lakes in the Puget Lowland. The unit is comprised of silt, clayey silt, and silty clay with scattered interbeds of fine sand. Scattered limestone concretions that are of cobble and boulder size may also exist. In places, soils of this unit have interbeds and thin lenses of cohesionless silt and fine sand with fine organic debris. Glaciolacustrine deposits have a low permeability vertically, but can be moderately horizontally along sandy layers or lenses.

Till [Qpgt].

This unit was deposited as lodgment till or ablation till and was subsequently overridden by ice. This unit is generally a non-clayey diamict composed of a heterogeneous mixture of silt, sand, and gravel with nonplastic to low plasticity fines. It is sometimes referred to as “hardpan” due to its very dense nature and a concrete-like appearance. It has a low permeability.

Till-like Deposits [Qpgd].

These till-like sediments are nonsorted or poorly sorted granular deposits exhibiting a wide range of grain sizes (a diamicton), and are generally intermediate between till and outwash. They may have been reworked by subglacial streams flowing in channels and pools directly beneath the ice. They are comprised of very dense, silty sand and sandy silt, with varying percentages of gravel and scattered traces of clay. The permeability of the till-like deposit is low to moderate, but can locally be high.

Glaciomarine Drift [Qpgm].

Soils of this unit were deposited in lakes or marine water by a combination of the slow settling of clay and silt particles in quiet waters, and the episodic and variable deposition of clastic debris from melting icebergs. The Qpgm sediments generally consist of a heterogeneous and variable mixture of clay, silt, sand, and gravel (clayey diamicton) and commonly grade into and contain layers of Qpgl. Although they can be high to low permeability due to their highly variable grain size composition, they most commonly are of low permeability. Even where they have a high permeability, the permeable soil is not laterally extensive, and therefore is not readily recharged.

Soil

The subsurface conditions at the site were characterized in a multi-step process. Soils encountered in the explorations were first described using soil classification terms and then appropriate geologic unit names were assigned (as described above). The soils encountered in our current borings included fill, normally consolidated sediments, and overconsolidated sediments; these units are described below from ground surface to depth.

In general, 1 to 12 feet of fill underlies the proposed plant site. Beneath asphalt pavements, gravelly base course was encountered and, in borings PB-7A and PB-7B, cobbles 4 to 8 inches in diameter were observed. Site fill consisted of medium dense, slightly silty, gravelly sand and very loose, silty, fine sand with scattered roots, organics and wood debris.

Beneath the fill, layers of normally consolidated Qvro, Qvrl, and Qvi were encountered. These deposits ranged from about 7 to 29 feet thick and consisted of several soil types and densities. These soils included medium dense to very dense trace gravelly to gravelly, slightly silty to silty, fine sand; medium dense to very dense, slightly silty, sandy gravel with scattered cobbles; medium dense slightly clayey to clayey, fine sandy silt; and very dense fine sandy silt.

Overconsolidated sediments were observed beneath the soil layers described above. The first overconsolidated sediments encountered were Qvd and Qvt. These layers were about 31 to 74 feet thick. They consisted of very dense, trace to slightly clayey, trace to slightly gravelly, silty sand and trace gravelly to gravelly, sandy silt. Dense to very dense, silty sand and gravelly sand were also observed.

Qvlc was noted at the bottom of boring PB-2 and towards the bottom of the Qvd layer in boring PB-10. The Qvlc was about 2 to 11 feet thick and consisted of very dense silty, fine sand to fine sandy silt as well as hard, silty clay.

In boring PB-10, a layer was encountered that could be defined as either Qva or Qpnf. This layer began at about 89 feet and was encountered to the bottom of the boring. It consisted of very dense, slightly gravelly, silty, fine to medium sand with a trace of organics.

Qpgo was encountered near the bottom of several borings and was found to be 40 feet or more thick in some areas. In boring PB-12, the thickest Qpgo layer had a thin layer of Qpgd within it. This soil consisted of very dense, trace to slightly silty, trace gravelly to gravelly sand, gravelly sand, and fine sandy silt. Scattered to numerous cobbles were also observed.

In borings PB-2 and PB-12, 4- to 14-foot-thick layers of Qpgl were encountered. They consisted of hard, silty clay; very dense, clayey, silty sand; and very dense, slightly silty to silty, fine sand. An organic odor and scattered organics were noted.

The remainder of the soil layers described below were encountered only in our deepest boring, PB-12. Three to 15-foot-thick layers of Qpgd were observed. The soil composition varied from very dense, silty sand to very stiff, silty, clayey sand to very dense, silty gravelly sand and slightly clayey, fine sandy silt. Scattered wood fragments were noted in several samples.

A 17-foot-thick layer of Qpgt was logged in boring PB-12. It consisted of very dense, silty, gravelly sand to very dense, silty sand.

The thickest geologic layer observed at the site was Qpnl; it measured about 240 feet thick. The layer was noted again at the bottom of boring PB-12. The Qpnl varied in density and consistency. It consisted of hard, slightly fine sandy, slightly clayey to clayey silt; hard, slightly clayey to clayey, fine sandy silt; very dense, silty, fine sand; very dense, slightly clayey, silty, fine sand; and hard, slightly fine sandy, silty clay. Scattered organic seams, numerous organic fragments, and organic-rich seams were observed within the unit.

Finally, a 54-foot-thick layer of Qpgm was logged near the bottom of boring PB-12. It consisted of hard, silty clay to slightly sandy, silty clay. In addition, very dense, slightly clayey to clayey, silty, gravelly sand to slightly gravelly, silty sand was observed.

Groundwater

Groundwater levels were obtained during drilling of our current borings and from monitoring well and VWP readings. In addition, data from the previous exploration logs were also evaluated. The groundwater levels noted on our logs represent the level at that particular time when the reading was made.

Measurement of groundwater levels at SB- (previous CH2M HILL borings) and PB-series borings started in April 2003 and is ongoing. The groundwater levels measured at the PB- and SB- series borings are provided in Attachment F. Based on these groundwater level elevations and a review of the site geology, different hydrogeologic units are likely present at the site.

Shallow groundwater levels measured at monitoring wells completed within the upper Qvro and Qvrl soils may represent the unconfined water table. Piezometric contours for these shallow groundwater levels are presented in Figure 3. Water was typically encountered between 2 and 7 feet below ground surface at monitoring wells completed within the shallow soils. Figure 3 indicates that shallow soils have a steep hydraulic gradient toward the west and mirror the ground surface.

Water levels measured at VWPs installed within deeper soil units indicate varying groundwater elevations. Water level measurements within deep sand units such as the Qpgo indicate artesian groundwater conditions (water levels above ground surface). Additional water level measurements are necessary to evaluate vertical hydraulic gradients and to determine the relationship between soil units and groundwater elevations.

LIMITATIONS

The interpretation and conclusions presented in this data report are based on site conditions as they presently exist, and further assume that the previous and current exploratory borings and groundwater readings are representative of the subsurface conditions at the site. Within the limitations of the scope, schedule, and budget, the soil and groundwater descriptions and geologic interpretations presented in this data report were prepared in accordance with generally accepted professional geotechnical engineering principles and practice in this area at the time this report was prepared. We make no other warranty, either express or implied. Our descriptions and interpretations were based on our understanding of the project as described in this report and the site conditions as interpreted from the current and previous explorations and groundwater readings. We understand that, if the Route 9 site is chosen as the treatment plant and/or the IPS shaft location, additional geotechnical field explorations and studies will be conducted in order to obtain sufficient information for their design.

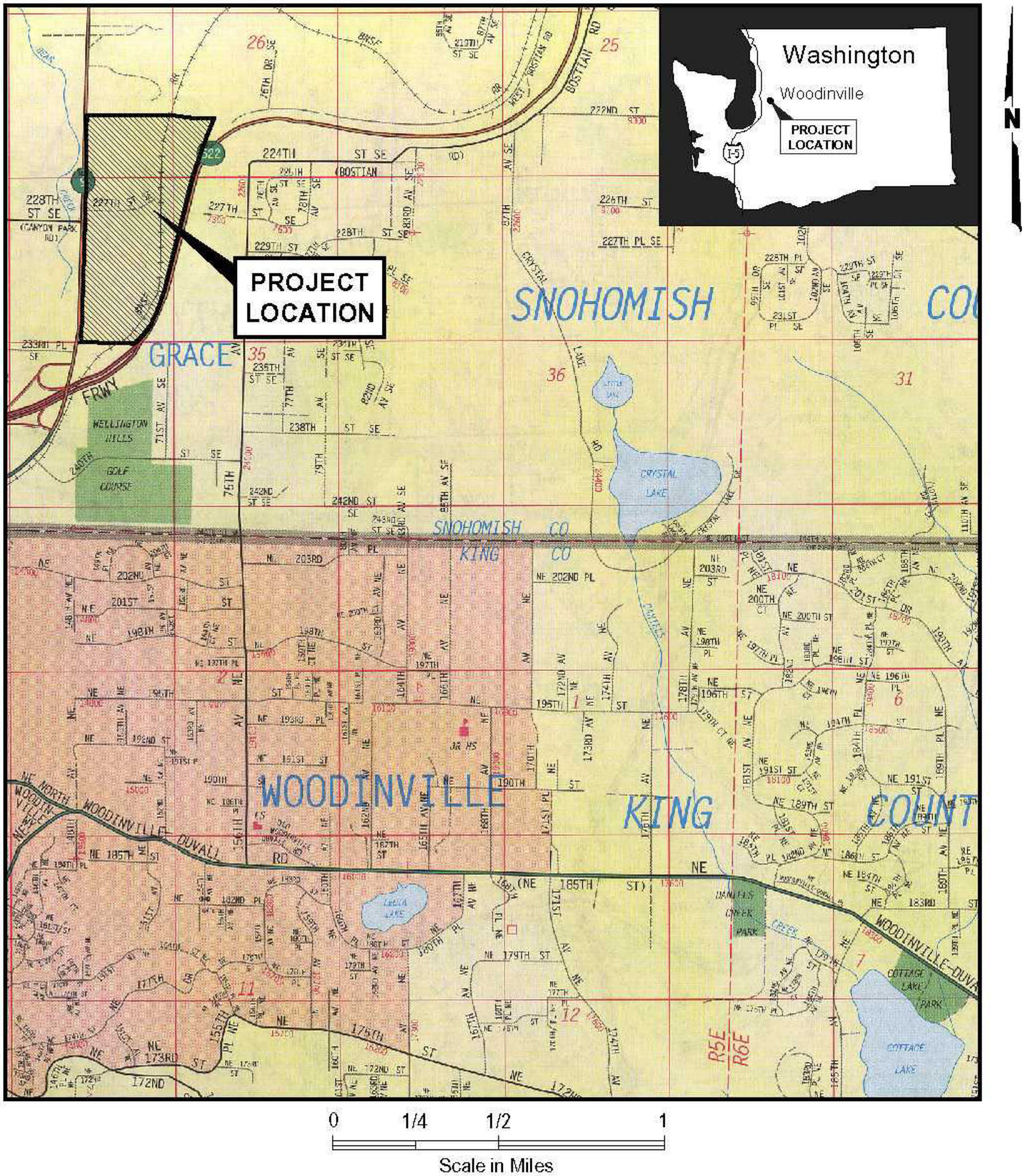
Except for the discussion included in this report, the scope of our services did not include any environmental assessment or evaluation regarding the presence or absence of wetlands or hazardous or toxic materials in the soil, surface water, groundwater or air on or below the site.

This data report was prepared for the exclusive use of King County, CH2M HILL, and other members of the design team. It should be made available to prospective contractors and/or the contractor for information on factual data only, and not as warranty of subsurface conditions, such as these interpreted from the boring logs and discussions of subsurface conditions included in this report. Shannon & Wilson, Inc., has prepared the attachment "Important Information About Your Geotechnical Report," to assist you and others in understanding the use and limitations of our reports. This attachment is included in Attachment G.

Unanticipated soil conditions are commonly encountered and cannot fully be determined by merely taking soil samples from borings, or reviewing previous borings. Such unexpected conditions frequently require that additional expenditures be made to attain properly constructed projects. Therefore, some contingency fund is recommended to accommodate such potential extra cost.

REFERENCES

CH2M HILL and Shannon and Wilson, 2002. *Siting Study Phase 3 Geotechnical Data Report, Route 9 and Edmonds-Unocal Site.* Report prepared for King County Wastewater Treatment Division.



Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

VICINITY MAP

July 2003

21-1-09869-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 1

NOTE

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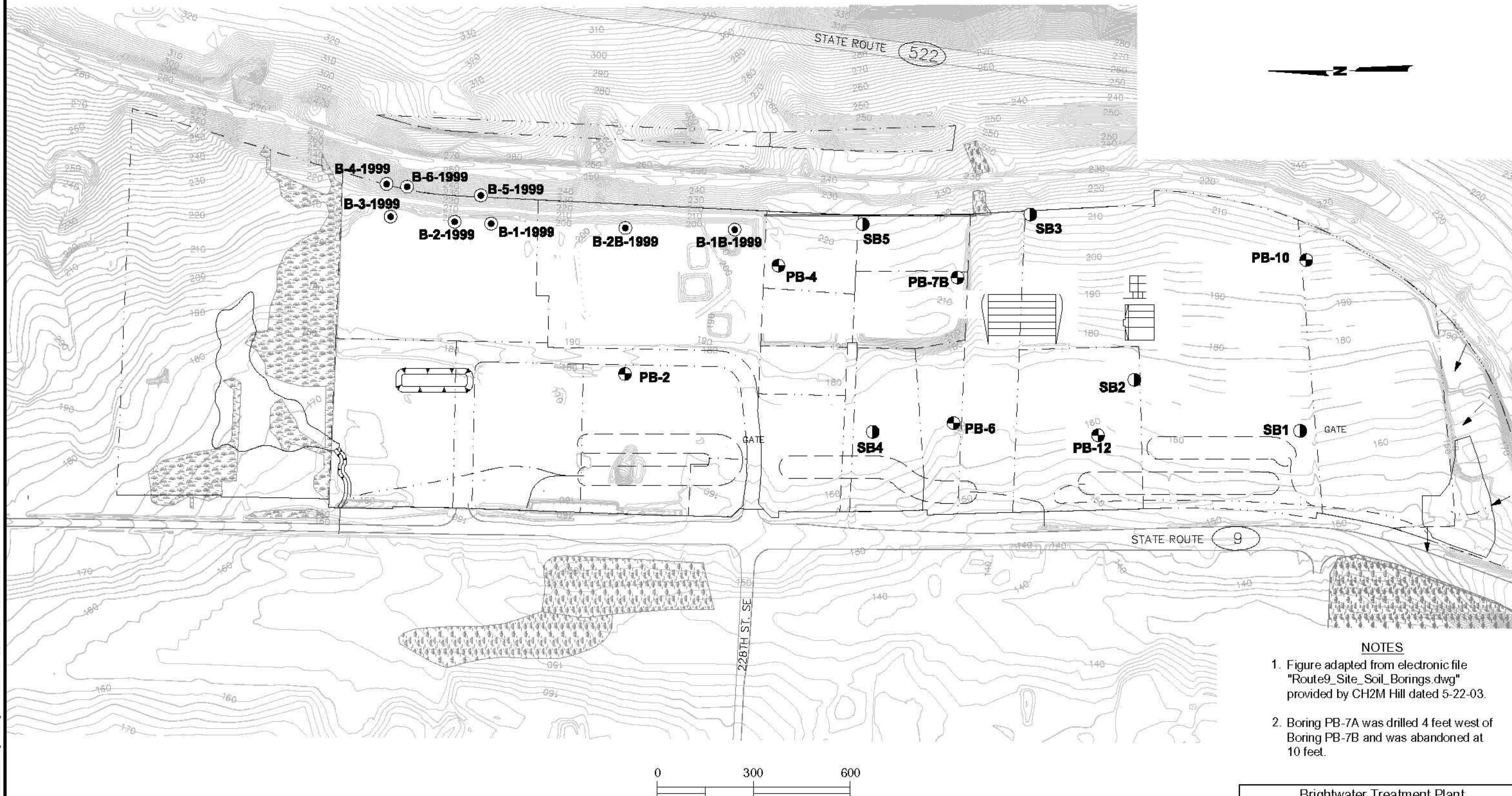


NOTES

1. Figure adapted from electronic file "Route9_Site_Soil_Borings.dwg" provided by CH2M Hill dated 5-22-03.
2. Boring PB-7A was drilled 4 feet west of Boring PB-7B and was abandoned at 10 feet.

LEGEND

PB-2 Current Shannon & Wilson Boring Designation and Surveyed Location (Completed 2003)

SB-4 Previous CH2M Hill Boring Designation and Approximate Location (Completed 2001)

B-1-1999/ B-1B-1999 Previous Nelson-Couvrette & Associates, Inc. Boring Designation and Approximate Location and Year Completed

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

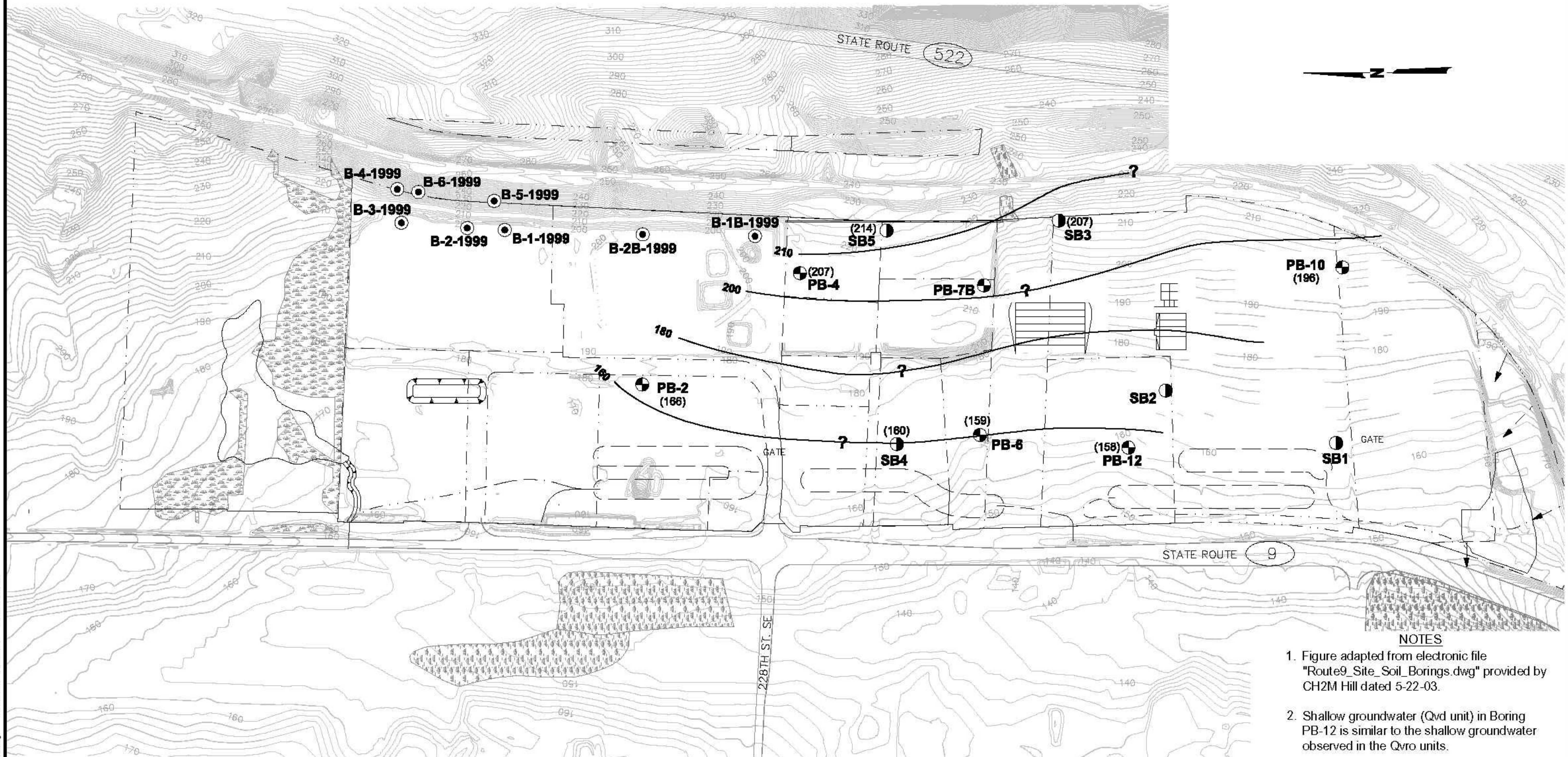
SITE AND EXPLORATION PLAN

July 2003 21-1-09869-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 2

File: I:\Drafting\211\09869-002\21-1-09869-002 Fig. 2.dwg Date: 07-16-2003 Author: SAC



NOTES

1. Figure adapted from electronic file "Route9_Site_Soil_Borings.dwg" provided by CH2M Hill dated 5-22-03.
2. Shallow groundwater (Qvd unit) in Boring PB-12 is similar to the shallow groundwater observed in the Qvro units.
3. Boring PB-7A was drilled 4 feet west of Boring PB-7B and was abandoned at 10 feet.

LEGEND

PB-2	Current Shannon & Wilson Boring Designation and Surveyed Location (Completed 2003)
SB-4	Previous CH2M Hill Boring Designation and Approximate Location (Completed 2001)
B-1-1999/ B-1B-1999	Previous Nelson-Couvrette & Associates, Inc. Boring Designation and Approximate Location and Year Completed
180	Approximate Shallow Groundwater Contour Elevation in Feet
(166)	Approximate Groundwater Level Elevation at Well in Feet

0 300 600

Scale in Feet

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

PIEZOMETRIC CONTOURS FOR SHALLOW GROUNDWATER IN Qvro-Qvrl SOILS

July 2003 21-1-09869-002

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FIG. 3

File: I:\Drafting\211\09869-002\21-1-09869-002 Fig. 3.dwg Date: 07-16-2003 Author: SAC

ATTACHMENTS

A Proposed Treatment Plant Field Explorations

B Proposed Treatment Plant Geotechnical Laboratory Testing Procedures and Results

C Proposed IPS Field Exploration

D Proposed IPS Geotechnical Laboratory Testing Procedures and Results and Radiocarbon Dating Results

E Environmental Laboratory Test Results

F Important Information About Your Geotechnical/Environmental Report

ATTACHMENT A

PROPOSED TREATMENT PLANT FIELD EXPLORATIONS

Attachment A
Proposed Treatment Plant Field Explorations

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INTRODUCTION

The current subsurface exploration program for the proposed SR-9 treatment plant site consisted of drilling six borings designated PB-2, PB-4, PB-6, PB-7A, PB-7B, and PB-10. Boring PB-7A was abandoned at 10 feet because the augers could not be kept vertical due to near surface rocks. The boring was moved four feet east and drilled as boring PB-7B. The locations of the explorations are shown on the Site and Exploration Plan, presented as Figure 2 after the main text of this data report. Other members of the pre-design team surveyed the exploration locations and elevations. In addition, previous explorations from other studies were used. These explorations are also shown on Figure 2 after the main text of this report; CH2M HILL provided their locations.

SOIL CLASSIFICATION

An engineer from Shannon & Wilson, Inc. was present throughout the drilling and sampling operations for the current borings. Our field engineer retrieved representative soil samples and prepared a descriptive field log of the explorations. Classification of the boring samples was based on American Society for Testing and Materials (ASTM) Designation: D 2487-98, Standard Test Method for Classification of Soil for Engineering Purposes, and ASTM Designation: D 2488-93, Standard Recommended Practice for Description of Soils (Visual-Manual Procedure). The Unified Soil Classification System (USCS), as described on Figure A-1 of this attachment, was used to classify the soils encountered in the soil borings. For quality assurance purposes, an engineering geologist also went through the samples and classified the soil in our laboratory. The boring logs in this report represent our interpretation of the contents of the field logs and incorporate the results of our geotechnical laboratory testing which are described in Attachment B.

CURRENT SOIL BORINGS

The subsurface conditions at the proposed SR-9 treatment plant site were explored with six soil borings. Several more borings were originally planned, but were not completed during this phase of the work. The borings were drilled to depths of 10 to 110.3 feet. The soil borings were accomplished between April 2 and April 10, 2003.

Drilling Procedures

Geo-Tech Explorations of Kent, Washington, drilled the soil borings under subcontract to Shannon & Wilson, Inc. They employed a truck-mounted, drill rig; the borings were drilled using a combination of hollow-stem auger and open-hole mud-rotary methods. Hollow-stem auger drilling was performed to a depth of 10 feet below ground surface (bgs). In general, soil samples were collected every 2.5 feet to 30 feet. Field screening was performed using a photoionization (PID) meter, which provides a qualitative measurement of the volatile organics in soil.

Once drilling had advanced to 10 feet bgs (and was therefore below groundwater), the borings were advanced to depth using mud rotary drilling techniques. Soil samples were collected approximately every 5 feet for geologic classification and testing purposes. During the mud rotary drilling, the auger flights were left in the borehole as a temporary casing.

The hollow-stem auger was an 11-inch outside-diameter (O.D.) continuous flight auger. Samples were taken from the bottom of the hollow-stem. Mud-rotary borings are advanced by circulating thick drilling mud from the rig down through rods to a 6-inch-diameter tri-cone bit at the bottom of the borehole. The drilling mud is a mixture of bentonite powder and water. Cuttings are transported from the bottom of the borehole to the surface by drilling mud flowing between the drilling rods and the sides of the borehole. The cuttings are deposited in a settling tank at the ground surface and the mud is recirculated.

PID measurements were non-detect or very low in all six borings. In boring PB-7B sample S-1, an odor was detected using olfactory methods; an environmental sample was obtained and turned in for testing. Based on the zero PID readings and visual/olfactory methods of observation, no signs of potential contamination were noted in any of the boreholes, except boring PB-7B sample S-1. Therefore, no environmental samples were taken (except as noted above), and the drummed soil cuttings and drilling mud were disposed of by the drilling subcontractor. The test results for the environmental sample from boring PB-7B sample S-1 indicated no volatile contamination (as shown in Attachment E); therefore, the driller disposed of the two decontamination water drums. No samples of the decontamination water were collected for laboratory analysis.

Prior to moving to a new borehole location after boring PB-7B was complete, drilling and non-disposable sampling equipment were decontaminated using a solution of Alconox and water, with a final tap water rinse. Decontamination fluids were drummed separately from soil cuttings and drilling mud, and were labeled and stored adjacent to the borehole until environmental testing was completed. A total of 2 drums of decontamination water were generated during this field investigation.

After completion of drilling and sampling, five borings had monitoring wells installed. Three of the boreholes also had a vibrating wire piezometer (VWP) installed, and one borehole had two VWPs installed. A description of the monitoring well and VWP installations and measurements is included later in this attachment.

Soil Sampling

During drilling, representative soil samples were generally obtained at 2.5-foot intervals to a depth of 30 feet and at 5-foot intervals thereafter at each boring location. The environmental sample from PB-7B was submitted to OnSite Environmental Laboratory of Redmond, Washington, and was analyzed for Northwest Total Petroleum Hydrocarbon (NWTPH-HCID). A copy of the laboratory data package is presented in Attachment E. The sample indicated that hydrocarbons were non-detect. In our opinion, the odor noted in the sample was probably organics.

To obtain relatively disturbed soil samples from borings, Standard Penetration Tests (SPT) were performed in general accordance with the ASTM Designation: D 1586, Test Method for Penetration Test and Split-Barrel Sampling of Soils (ASTM, 2001). In the SPT, a 2-inch O.D., 1.375-inch I.D., split-spoon sampler is driven with a 140-pound hammer falling 30 inches. The number of blows required to achieve each of three 6-inch increments of sampler penetration is recorded. The number of blows required to cause the last 12 inches of penetration is termed the Standard Penetration Resistance (N-value), or blow count, N. When penetration resistances exceed 50 blows for 6 inches or less of penetration, the test is terminated and the number of blows and inches driven are recorded. The samples were sealed in jars and returned to our laboratory for testing.

The SPTs were recorded by our field representative and are plotted on the boring logs. The N-values are designated with an upright triangle. These values are empirical parameters that provide a means of evaluating the relative density or compactness of cohesionless (granular) soils and the relative consistency (stiffness) of cohesive soils. The terminology used to describe the relative density or consistency of the soil is presented on Figure A-1. The samples were classified and recorded on field logs by our representative. The samples were sealed in jars and returned to our laboratory for testing.

Monitoring Well Installation

As part of the investigation, observation (monitoring) wells were installed in five of the boreholes (PB-2, PB-4, PB-6, PB-7B, and PB-10) to evaluate groundwater conditions that may be encountered during construction. No monitoring well was installed in boring PB-7A. The well screen and riser pipe was installed through the near-surface augers. The drilling mud was pumped from the hole prior to installation of the well screen and riser pipe.

The monitoring wells were constructed of new, commercially fabricated, threaded, flush-jointed, 2-inch-diameter Schedule 40 polyvinyl chloride (PVC) pipe. Well screen generally consisted of new, commercially fabricated, threaded, 10-foot-long, flush-jointed, 2-inch-diameter, 0.01-inch-wide machine-slotted screen. A silica sand filter pack was poured in the annular space between the boring and the well screen to about 2 to 3 feet above the screen. A minimum 2-foot-thick bentonite seal was placed in the annulus above the filter pack to within 3 feet of the surface. The wells were completed flush with the elevation of the surrounding grade by placing an 8-inch-diameter flush-mount steel monument over the top of the borehole. The steel monuments were set in-place with quick set concrete.

Monitoring Well Development

Well development was performed to improve the hydraulic connection between the aquifer and the screened portion of the monitoring well. The development procedure consisted of a combination of surging and pumping. The saturated screened section of each observation well was surged and pumped simultaneously to remove water, drilling mud and sediment from the bottom of the well. Development equipment consisted of a Waterra™ 2-inch-diameter, Acetal surge block/check-valve combination attached to the bottom of a dedicated section of semi-rigid high-density polyethylene (HDPE) tubing. The sediment load of the purged groundwater was measured periodically by filling a graduated container and observing the amount of sediment that settled out. Wells were pumped until there was no further observed improvement in water quality. There were no signs of potential contamination in the well development water.

Monitoring Well Measurements

Water levels in each of the monitoring wells were measured on May 7, 2003. Measurements were made using an electronic water level indicator and were measured relative to the top of the PVC well casing. Data were later converted to elevation in feet relative to the NAVD 88 datum and are provided in Table 1 in the main text of this report.

Vibrating Wire Piezometer Installation

Five vibrating wire piezometers (VWPs) were installed in completed boring at PB-2, PB-4, PB-7B, and PB-10. Two VWPs were installed in boring PB-10. No VWPs were installed in PB-6 or PB-7A. The VWP depths are shown on the boring log in Figures A-3 through A-8. The VWPs were calibrated, hung at the target installation depths, and surrounded with filter pack sand from about two feet below the VWP tip to about two feet above the VWP. Bentonite chips were used to fill the annular space within the borehole except at well screen (see above) and VWP depths.

Vibrating Wire Piezometer Measurements

Measurements at each of the VWPs were performed on May 7, 2003. Measurements were made using a VWP readout box. Data were later converted to feet of water and subsequently to elevation in feet relative to the NAVD 88 datum. The elevations are provided in Table 1 in the main text of this report.

Groundwater Observations

Groundwater was noted during drilling and is shown on the boring logs. Additional groundwater information has been obtained by taking monitoring well and VWP measurements as described above.

Boring Logs

The current boring logs for the proposed site are presented in this attachment. A boring log is a written record of the subsurface conditions encountered. It graphically illustrates the interpreted geologic units (layers) encountered in the boring and the USCS symbol of each geologic layer. It also includes the natural water content and blow count. Other information shown on the boring logs includes the groundwater level observations made during drilling, monitoring well and VWP measurements, ground surface elevation (NAVD 88), types and depths of sampling, and Atterberg Limits (where tested). Figure A-2 presents the geologic unit explanation and descriptions.

PREVIOUS FIELD EXPLORATIONS

Several previous field explorations by CH2M HILL and Nelson-Couvrette & Associates (NCA) are also included on the site and exploration plan in the main text of this report. The exploration logs are presented as Figures A-9 to A-18. The previous CH2M HILL borings were completed in an earlier phase of the Brightwater project and are designated borings SB1 through SB5. The NCA borings were completed for two other projects; CH2M HILL provided their locations. CH2M HILL also provided elevations for three of the NCA borings. Several of the previous explorations had groundwater level readings during drilling and some had readings from monitoring wells. These readings are included on the generalized subsurface profiles in the main text of the report.

REFERENCE

American Society for Testing and Materials (ASTM), 2003, 2003 Annual book of standards, Construction, v. 04.08, Soil and rock (I): D 420 – D 5779: West Conshohocken, Pa.

Shannon & Wilson, Inc. (S&W), uses a soil classification system modified from the Unified Soil Classification System (USCS). Elements of the USCS and other definitions are provided on this and the following page. Soil descriptions are based on visual-manual procedures (ASTM D 2488-93) unless otherwise noted.

S&W CLASSIFICATION OF SOIL CONSTITUENTS

- MAJOR constituents compose more than 50 percent, by weight, of the soil. Major consituents are capitalized (i.e., SAND).
- Minor constituents compose 12 to 50 percent of the soil and precede the major constituents (i.e., silty SAND). Minor constituents preceded by "slightly" compose 5 to 12 percent of the soil (i.e., slightly silty SAND).
- Trace constituents compose 0 to 5 percent of the soil (i.e., slightly silty SAND, trace of gravel).

MOISTURE CONTENT DEFINITIONS

Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, from below water table

ABBREVIATIONS

ATD	At Time of Drilling
Elev.	Elevation
ft	feet
FeO	Iron Oxide
MgO	Magnesium Oxide
HSA	Hollow Stem Auger
ID	Inside Diameter
in	inches
lbs	pounds
Mon.	Monument cover
N	Blows for last two 6-inch increments
NA	Not applicable or not available
NP	Non plastic
OD	Outside diameter
OVA	Organic vapor analyzer
PID	Photo-ionization detector
ppm	parts per million
PVC	Polyvinyl Chloride
SS	Split spoon sampler
SPT	Standard penetration test
USC	Unified soil classification
WLI	Water level indicator

GRAIN SIZE DEFINITION

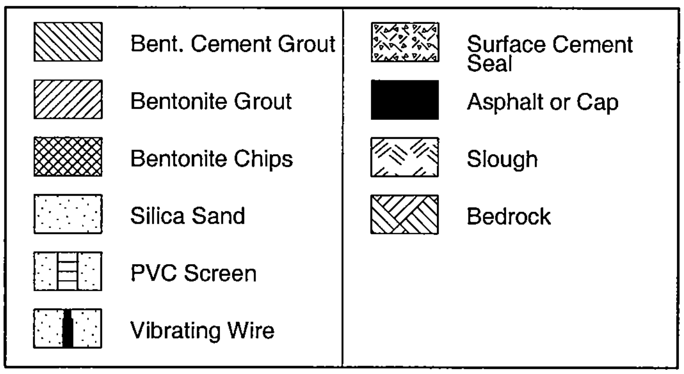
DESCRIPTION	SIEVE NUMBER AND/OR SIZE
FINES	< #200 (0.8 mm)
SAND*	
- Fine	#200 to #40 (0.8 to 0.4 mm)
- Medium	#40 to #10 (0.4 to 2 mm)
- Coarse	#10 to #4 (2 to 5 mm)
GRAVEL*	
- Fine	#4 to 3/4 inch (5 to 19 mm)
- Coarse	3/4 to 3 inches (19 to 76 mm)
COBBLES	3 to 12 inches (76 to 305 mm)
BOULDERS	> 12 inches (305 mm)

* Unless otherwise noted, sand and gravel, when present, range from fine to coarse in grain size.

RELATIVE DENSITY / CONSISTENCY

COARSE-GRAINED SOILS		FINE-GRAINED SOILS	
N, SPT, BLOWS/FT.	RELATIVE DENSITY	N, SPT, BLOWS/FT.	RELATIVE CONSISTENCY
0 - 4	Very loose	Under 2	Very soft
4 - 10	Loose	2 - 4	Soft
10 - 30	Medium dense	4 - 8	Medium stiff
30 - 50	Dense	8 - 15	Stiff
Over 50	Very dense	15 - 30	Very stiff
		Over 30	Hard

WELL AND OTHER SYMBOLS



Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

SOIL CLASSIFICATION AND LOG KEY

July 2003 21-1-09869-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-1
Sheet 1 of 2

BORING CLASS1 21-09869.GPJ SWNEW.GDT 7/16/03

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)
(From ASTM D 2487-98 & 2488-93)

MAJOR DIVISIONS			GROUP/GRAPHIC SYMBOL		TYPICAL DESCRIPTION
COARSE-GRAINED SOILS *(more than 50% retained on No. 200 sieve)*	Gravels *(more than 50% of coarse fraction retained on No. 4 sieve)*	Clean Gravels *(less than 5% fines)*	GW		Well-graded gravels, gravels, gravel/sand mixtures, little or no fines
			GP		Poorly graded gravels, gravel-sand mixtures, little or no fines
		Gravels with Fines *(more than 12% fines)*	GM		Silty gravels, gravel-sand-silt mixtures
			GC		Clayey gravels, gravel-sand-clay mixtures
	Sands *(50% or more of coarse fraction passes the No. 4 sieve)*	Clean Sands *(less than 5% fines)*	SW		Well-graded sands, gravelly sands, little or no fines
			SP		Poorly graded sand, gravelly sands, little or no fines
		Sands with Fines *(more than 12% fines)*	SM		Silty sands, sand-silt mixtures
			SC		Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS *(50% or more passes the No. 200 sieve)*	Silts and Clays *(liquid limit less than 50)*	Inorganic	ML		Inorganic silts of low to medium plasticity, rock flour, sandy silts, gravelly silts, or clayey silts with slight plasticity
			CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		Organic	OL		Organic silts and organic silty clays of low plasticity
	Silts and Clays *(liquid limit 50 or more)*	Inorganic	MH		Inorganic silts, micaceous or diatomaceous fine sands or silty soils, elastic silt
			CH		Inorganic clays or medium to high plasticity, sandy fat clay, or gravelly fat clay
		Organic	OH		Organic clays of medium to high plasticity, organic silts
HIGHLY-ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		PT		Peat, humus, swamp soils with high organic content (see ASTM D 4427)

NOTES

1. Dual symbols *(symbols separated by a hyphen, i.e., SP-SM, slightly silty fine SAND)*are used for soils with between 5% and 12% fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

2. Borderline symbols *(symbols separated by a slash, i.e., CL/ML, silty CLAY/clayey SILT; GW/SW, sandy GRAVEL/gravelly SAND)* indicate that the soil may fall into one of two possible basic groups.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

SOIL CLASSIFICATION AND LOG KEY

July 2003 | 21-1-09869-001

SHANNON & WILSON, INC.
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FIG. A-1
Sheet 2 of 2

GEOLOGIC UNIT DESCRIPTIONS

HOLOCENE DEPOSITS

f — FILL: Fill placed by humans, both engineered and nonengineered
Various materials, including debris; cobbles and boulders common; commonly dense or stiff if engineered, but very loose to dense or very soft to stiff if nonengineered.

QUATERNARY VASHON DEPOSITS

Qvro — RECESSIONAL OUTWASH DEPOSITS: Glaciofluvial sediment deposited as glacial ice retreated
Clean to silty Sand, gravelly Sand, sandy Gravel; cobbles and boulders common; loose to very dense.

Qvrl — RECESSIONAL LACUSTRINE DEPOSITS: Glaciolacustrine fine-grained sediment deposited in depressions during retreat or wastage of the glacial ice sheet.
Silt and fine Sand, locally clayey; very soft to very stiff.

Qvi — ICE-CONTACT DEPOSITS: Glacial deposits of diverse grain sizes deposited next to ice during wastage of the glacial ice sheet.
Stratified to irregular bodies of Gravel, Sand, Silt, and Clay; loose to dense.

Qvt — TILL: Lodgment till laid down along the base of the glacial ice
Gravelly silty Sand, silty gravelly Sand ("hardpan"); cobbles and boulders common; very dense.

Qvd — TILL-LIKE DEPOSITS (DIAMICT): Glacial deposit intermediate between till and outwash; subglacially reworked
Silty gravelly Sand, silty Sand, sandy Gravel; highly variable over short distances; cobbles and boulders common; dense to very dense.

Qva — ADVANCE OUTWASH: Glaciofluvial sediment deposited as the glacial ice advanced through the Puget Lowland
Clean to silty Sand, gravelly Sand, sandy Gravel; dense to very dense.

Qvlc — GLACIOLACUSTRINE DEPOSITS: Fined-grained glacial flour deposited in proglacial lake in Puget Lowland
Silty clay, Clayey Silt, with interbeds of Silt and fine Sand; locally laminated; scattered organic fragments near base; hard or dense to very dense.

QUATERNARY PRE-VASHON DEPOSITS

Qpnf — FLUVIAL DEPOSITS: Alluvial deposits of rivers and creeks
Clean to silty Sand, gravelly Sand, sandy Gravel; very dense.

Qpnl — LACUSTRINE DEPOSITS: Fine-grained lake deposits in depressions, large and small
Fine sandy Silt, silty fine Sand, clayey Silt; scattered to abundant fine organics; dense to very dense or very stiff to hard.

Qpgo — OUTWASH: Glaciofluvial sediment deposited as the glacial ice advanced through the Puget Lowland
Clean to silty Sand, gravelly Sand, sandy Gravel; very dense.

Qpgl — GLACIOLACUSTRINE DEPOSITS: Fine-grained glacial flour deposited in proglacial lake in Puget Lowland
Silty Clay, clayey Silt, with interbeds of Silt and fine Sand; very stiff to hard or very dense.

Qpgt — TILL: Lodgement till laid down along the base of the glacial ice.
Gravelly, silty Sand, silty gravelly Sand ("hardpan"); cobbles and boulders common; very dense,

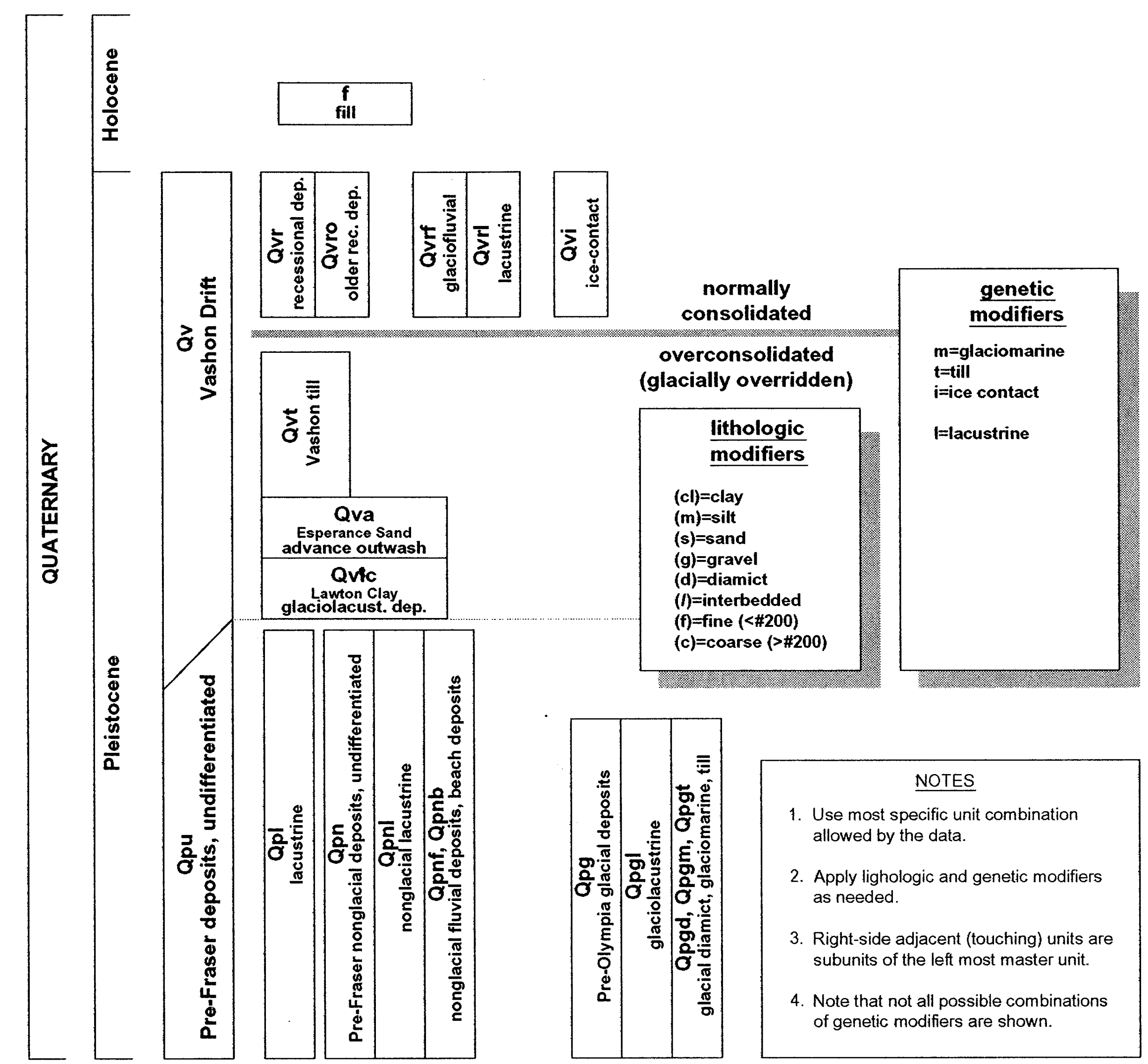
Qpgd — TILL-LIKE DEPOSITS (DIAMICT): Glacial deposits intermediate between till and outwash; subglacially reworked.
Silty gravelly Sand, silty Sand, sandy Gravel; highly variable over short distances; cobbles and boulders common; very dense.

Qpgm — GLACIOMARINE DEPOSITS: Till-like deposit with clayey matrix deposited in proglacial lake by icebergs, floating ice, and gravity currents.
Heterogenous and variable mixture of Clay, Silt, Sand, and Gravel; rare shells; cobbles and boulders common; very dense or hard.

NOTE

The description of each geologic unit includes only general information regarding the environment of deposition and basic soil characteristics.

GEOLOGIC UNIT EXPLANATION FOR THE PROPOSED BRIGHTWATER TREATMENT PLANT AT THE SR-9 SITE



NOTE

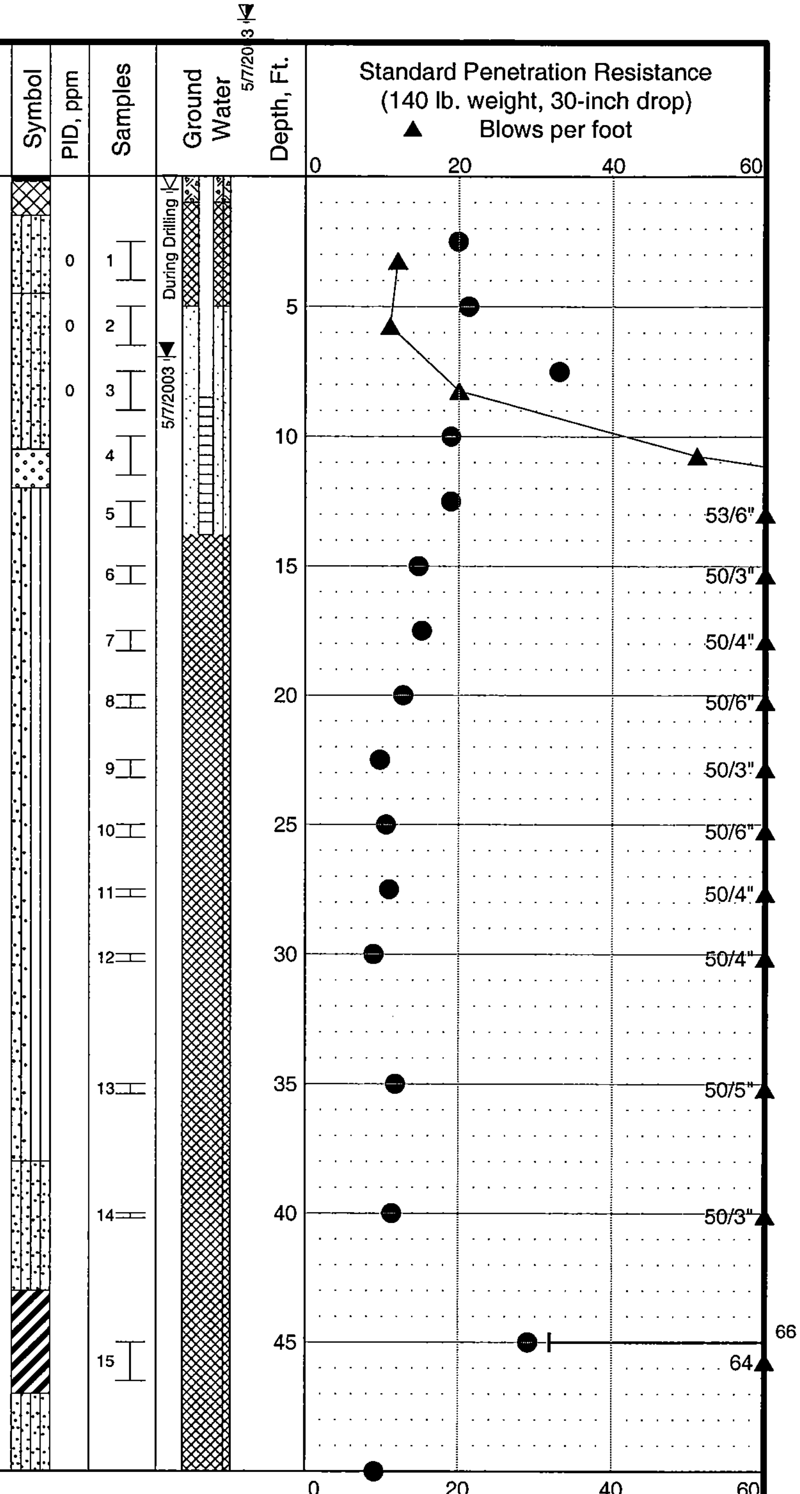
Figure adapted from "Master List of Geologic Units for the Brightwater Project Area, Jan. 2003" prepared and provided by the UW Seattle-Area Geologic Mapping Project 12-19-02 Version.

Brightwater Treatment Plant Route 9 Site Woodinville, Washington	
GEOLOGIC UNIT EXPLANATION AND DESCRIPTIONS	
July 2003	21-1-09869-002
SHANNON & WILSON, INC. Geotechnical and Environmental Consultants	FIG. A-2

File: I:\Drafting\211\09869-002\21-1-09869-002 Geologic Units.dwg Date: 07-16-2003 Author: SAC

SOIL DESCRIPTION Coordinates: N: 619,518 E: 1,647,029 Surface Elevation: 172.7 Ft. Datum: NAVD88	Depth, Ft.
Asphalt.	0.2
2-inch minus crushed rock; (f).	1.5
Medium dense, dark brown-gray, silty, fine SAND to fine sandy SILT; moist; trace of clay; scattered organics; (Qvro) SM/ML.	4.5
Medium dense, brown, silty, fine SAND interbedded with, trace to slightly silty, fine to medium SAND; wet; scattered iron-oxide stains, laminated trace organics; (Qvro) SM/SP-SM.	10.5
(no description)	12.0
Very dense, reddish-brown, fine to coarse SAND; wet; trace of silt and gravel; numerous iron-oxide stains; (Qvro) SW.	
Very dense, gray, trace to slightly gravelly, silty SAND and sandy SILT; moist; layers of slightly silty, fine to medium sand; (Qvd) SM-ML. - observation during drilling: hard drilling from 20 to 38 feet - observation during drilling: gravelly at 29 feet	38.0
Very dense, gray, gravelly, silty SAND; moist; (Qvt) SM. - observation during drilling: very hard drilling at 38 feet	43.0
Hard, gray, silty CLAY; moist; scattered slightly silty, fine sand seams, blocky, faintly laminated; (Qvlc) CH. - observation during drilling: hard drilling from 43 to 47 feet	47.0

CONTINUED NEXT SHEET



LEGEND

Symbol	Meaning
*	Sample Not Recovered
I	Standard Penetration Test
	Piezometer Screen and Sand Filter
	Bentonite-Cement Grout
	Bentonite Chips/Pellets
	Bentonite Grout
∇	Ground Water Level ATD
▼	Ground Water Level in Well
▼	Ground Water Level in VWP

● % Water Content

Plastic Limit |—●—| Liquid Limit
Natural Water Content

NOTES

1. The boring was performed using HSA and Rotary Combined drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

LOG OF BORING PB-2

July 2003 21-1-09869-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-3
Sheet 1 of 3

MASTER_LOG2 21-09869.GPJ SHAN_WIL.GDT 7/16/03 Log: XHL Rev: CLBM Typ: LKD

SOIL DESCRIPTION

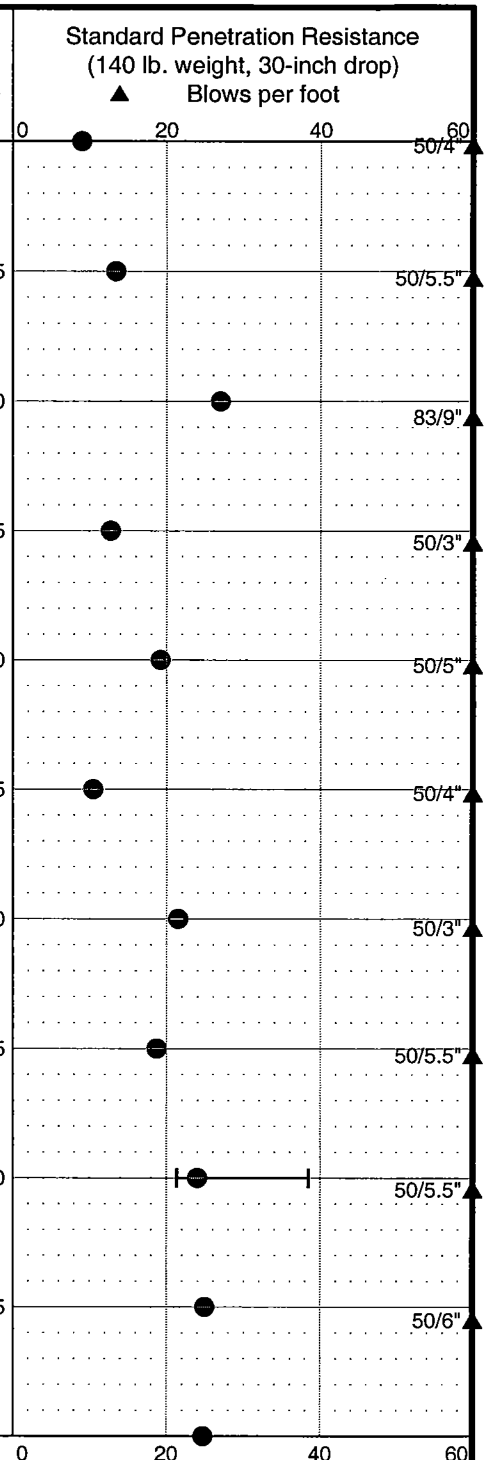
Coordinates: N: 619,518 E: 1,647,029

Surface Elevation: 172.7 Ft. Datum: NAVD88

Soil Description	Depth, Ft.	Samples
Very dense, gray, gravelly, silty SAND; moist; (Qvt) SM. - observation during drilling: very hard drilling from 47 to 77 feet		16, 17
Hard, gray, silty CLAY; moist; scattered fine sandy silt pockets; (Qvlc) CL.	59.0	18
Very dense, gray, slightly silty, slightly gravelly SAND to gravelly, fine to coarse SAND; wet; trace of silt; (Qpgo) SW-SM.	61.0	19, 20, 21
Very dense, dark gray, silty, fine SAND and fine sandy SILT; moist; occasional clay seams; massive; (Qpgo) SM.	77.0	22, 23
Hard, gray, silty CLAY; moist; locally laminated; (Qpgl) CL.	88.0	24
Very dense, gray, fine sandy SILT; moist; massive; (Qpgo) ML.	92.0	25

CONTINUED NEXT SHEET

Depth, Ft. | Symbol | PID, ppm | Samples | Ground Water | Depth, Ft.



LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level ATD
- Ground Water Level in Well
- Ground Water Level in VWP

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

Natural Water Content

NOTES

1. The boring was performed using HSA and Rotary Combined drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

LOG OF BORING PB-2

July 2003 21-1-09869-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-3
Sheet 2 of 3

MASTER_LOG2 21-09869.GPJ SHAN_WIL.GDT 7/16/03 Log: XHL Rev: CLBM Typ: LKD

SOIL DESCRIPTION Coordinates: N: 619,518 E: 1,647,029 Surface Elevation: 172.7 Ft. Datum: NAVD88	Depth, Ft.	Symbol	PID, ppm	Samples	Ground Water	Depth, Ft.	Standard Penetration Resistance (140 lb. weight, 30-inch drop) ▲ Blows per foot
BOTTOM OF BORING COMPLETED 4/10/2003	100.8			26			50/4"
Note: Hollow-stem auger was used to 10 feet, and mud-rotary techniques were used for the remainder of the borehole.						105	
						110	
						115	
						120	
						125	
						130	
						135	
						140	
						145	

0 20 40 60

● % Water Content

Plastic Limit |—●—| Liquid Limit
Natural Water Content

LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level ATD
- Ground Water Level in Well
- Ground Water Level in VWP

NOTES

1. The boring was performed using HSA and Rotary Combined drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

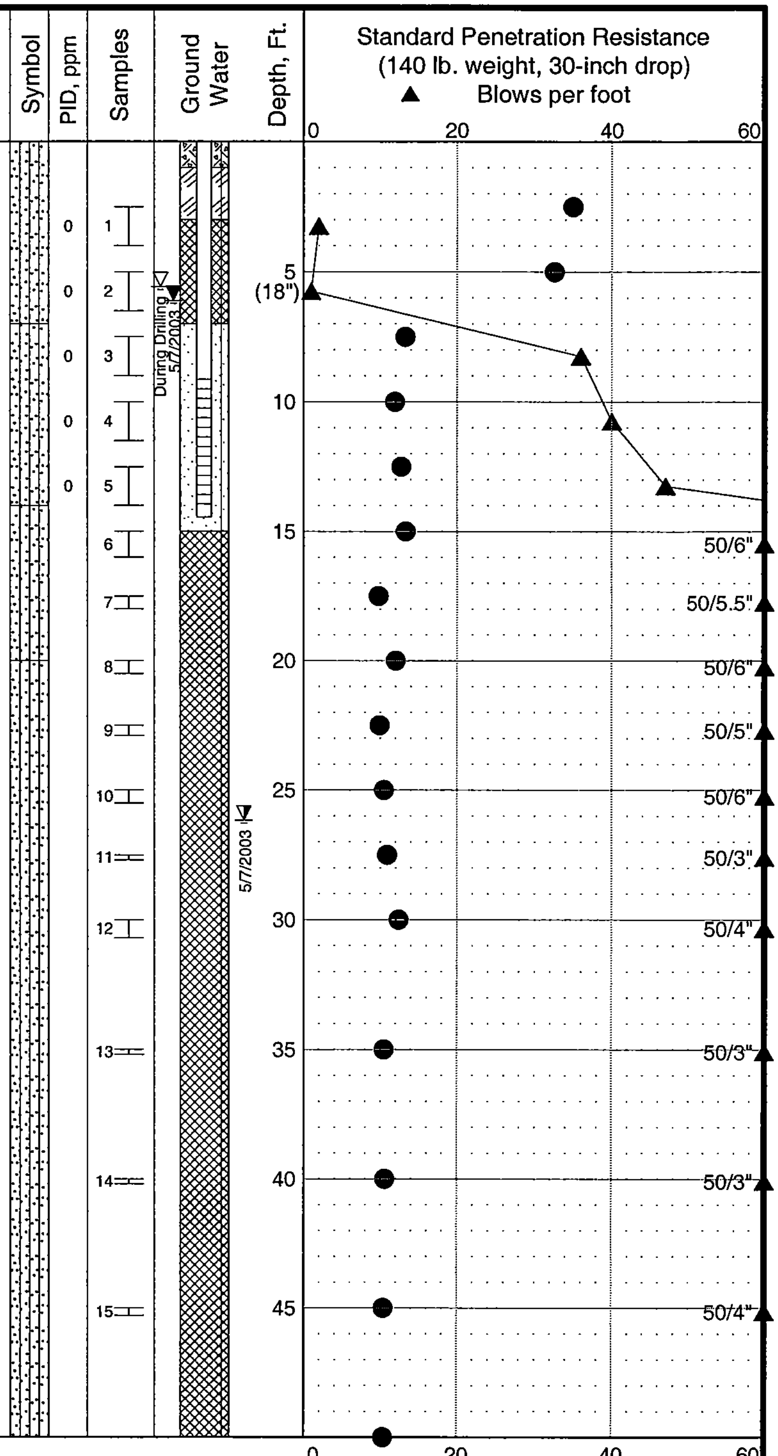
LOG OF BORING PB-2

July 2003 21-1-09869-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-3
Sheet 3 of 3

SOIL DESCRIPTION	Depth, Ft.
Coordinates: N: 619,040 E: 1,647,366 Surface Elevation: 213.1 Ft. Datum: NAVD88	
Very loose,light gray-dark reddish brown, silty, fine SAND to slightly clayey, silty fine to medium SAND; moist to wet; scattered organics and charcoal from 5 to 7 feet; (f) SM/SC. - observation during drilling: very easy drilling from 0 to 7 feet	7.0
Dense, dark brown to gray, slightly gravelly to gravelly, slightly silty to silty, fine to coarse SAND; scattered layers of clayey silt; (Qvro) SM/SW. - observation during drilling: moderate drilling from 7 to 14 feet	14.0
Very dense, gray, slightly gravelly, silty fine SAND; moist; till-like; (Qvd) SM. - observation during drilling: hard drilling from 14 to 20 feet	20.0
Very dense, gray, slightly clayey, slightly gravelly to gravelly, silty SAND and sandy SILT; moist; (Qvd) SM-ML. - observation during drilling: hard but smooth drilling from 20 to 26 feet; hard and rough drilling at 26 feet; hard drilling from 26 to 45 feet; hard and rough drilling from 45 to 53 feet	



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level ATD
- Ground Water Level in Well
- Ground Water Level in VWP

● % Water Content

Plastic Limit ├──●──┤ Liquid Limit
Natural Water Content

NOTES

1. The boring was performed using HSA and Rotary Combined drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

LOG OF BORING PB-4

July 2003 21-1-09869-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4
Sheet 1 of 3

SOIL DESCRIPTION

Coordinates: N: 619,040 E: 1,647,366

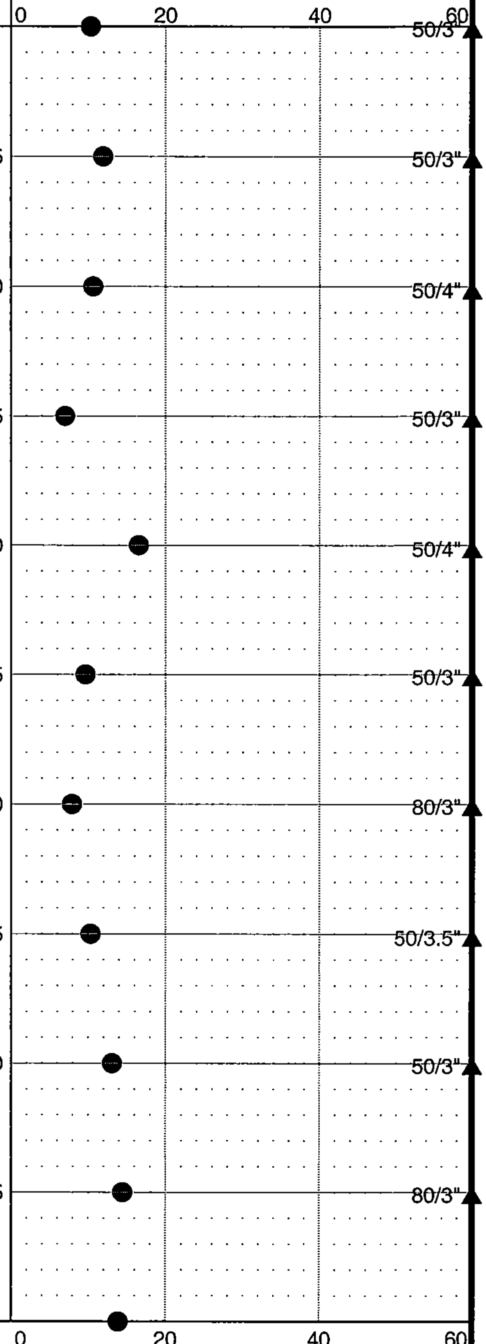
Surface Elevation: 213.1 Ft. Datum: NAVD88

Soil Description	Depth, Ft.	Samples
Very dense, gray, slightly clayey, slightly gravelly to gravelly, silty SAND and sandy SILT; (Qvd) SM-ML (cont.).	53.0	16
Very dense, gray, slightly clayey, slightly gravelly to gravelly, silty SAND; moist; interbedded layers of slightly silty sand and silt at 70 feet; (Qvt) SM. - observation during drilling: very rough drilling from 53 to 80 feet; drilling was significantly slowed down between 55 and 60 feet; hard drilling from 80 to 88 feet	88.0	17, 18, 19, 20, 21, 22, 23
Very dense, gray, slightly gravelly to gravelly, trace silty, fine to coarse SAND; moist to wet; (Qpgo) SP-SM. - observation during drilling: easier and smoother drilling from 88 to 106 feet; rough drilling at 106 feet		24, 25

CONTINUED NEXT SHEET

Columns: Depth, Ft. | Symbol | PID, ppm | Samples | Ground Water | Depth, Ft.

Standard Penetration Resistance
(140 lb. weight, 30-inch drop)
▲ Blows per foot



LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level ATD
- Ground Water Level in Well
- Ground Water Level in VWP

● % Water Content

Plastic Limit —●— Liquid Limit
Natural Water Content

NOTES

1. The boring was performed using HSA and Rotary Combined drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

LOG OF BORING PB-4

July 2003 21-1-09869-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4
Sheet 2 of 3

SOIL DESCRIPTION

Coordinates: N: 619,040 E: 1,647,366

Surface Elevation: 213.1 Ft. Datum: NAVD88

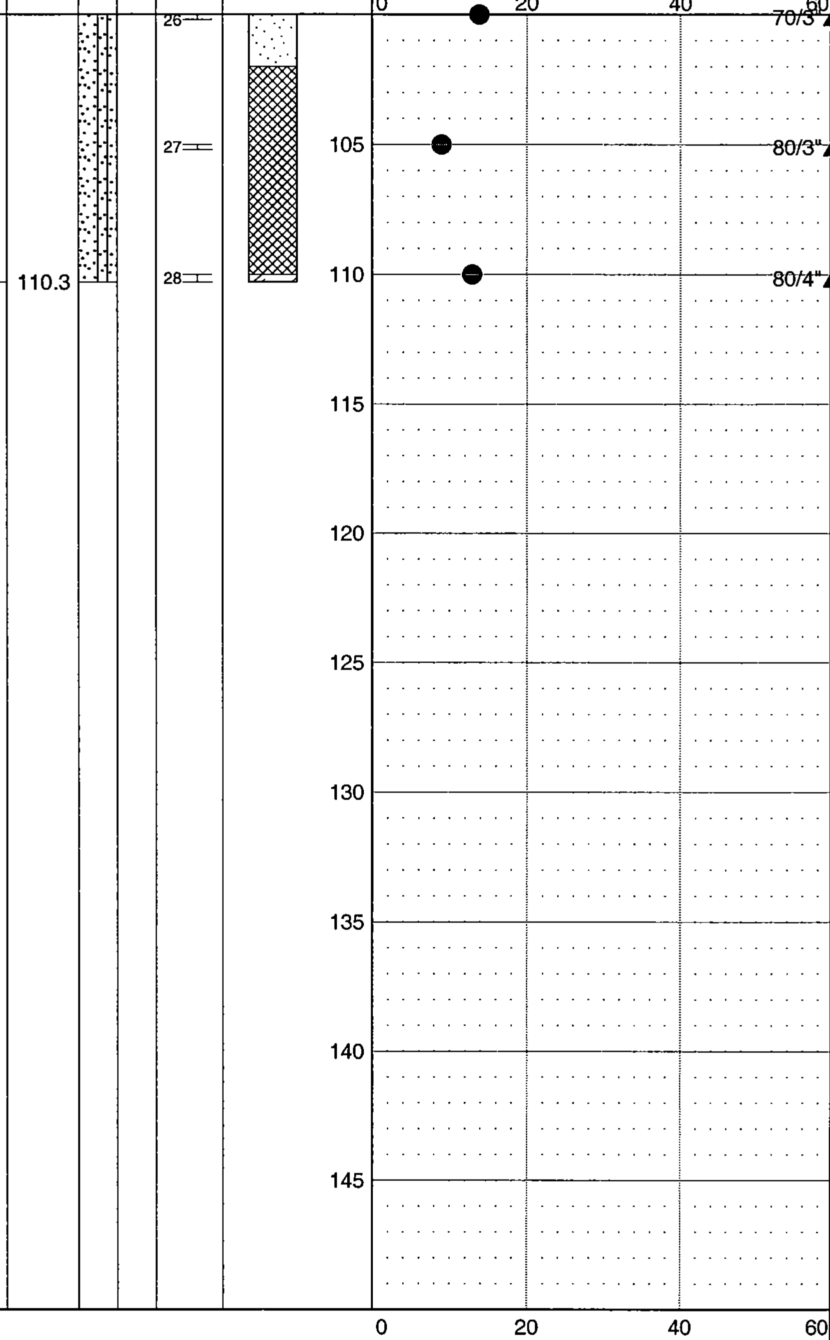
Depth, Ft.	Symbol	PID, ppm	Samples	Ground Water	Depth, Ft.	Standard Penetration Resistance (140 lb. weight, 30-inch drop) ▲ Blows per foot

Very dense, gray, trace gravelly to gravelly, trace silty to silty, fine to coarse SAND; (Qpgo) SP-SM (cont.).

110.3

BOTTOM OF BORING
COMPLETED 4/2/2003

Note: Hollow-stem auger was used to 10 feet, and mud-rotary techniques were used for the remainder of the borehole.



LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level ATD
- Ground Water Level in Well
- Ground Water Level in VWP

● % Water Content

Plastic Limit ├──●──┤ Liquid Limit
Natural Water Content

NOTES

1. The boring was performed using HSA and Rotary Combined drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

LOG OF BORING PB-4

July 2003 21-1-09869-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4
Sheet 3 of 3

SOIL DESCRIPTION

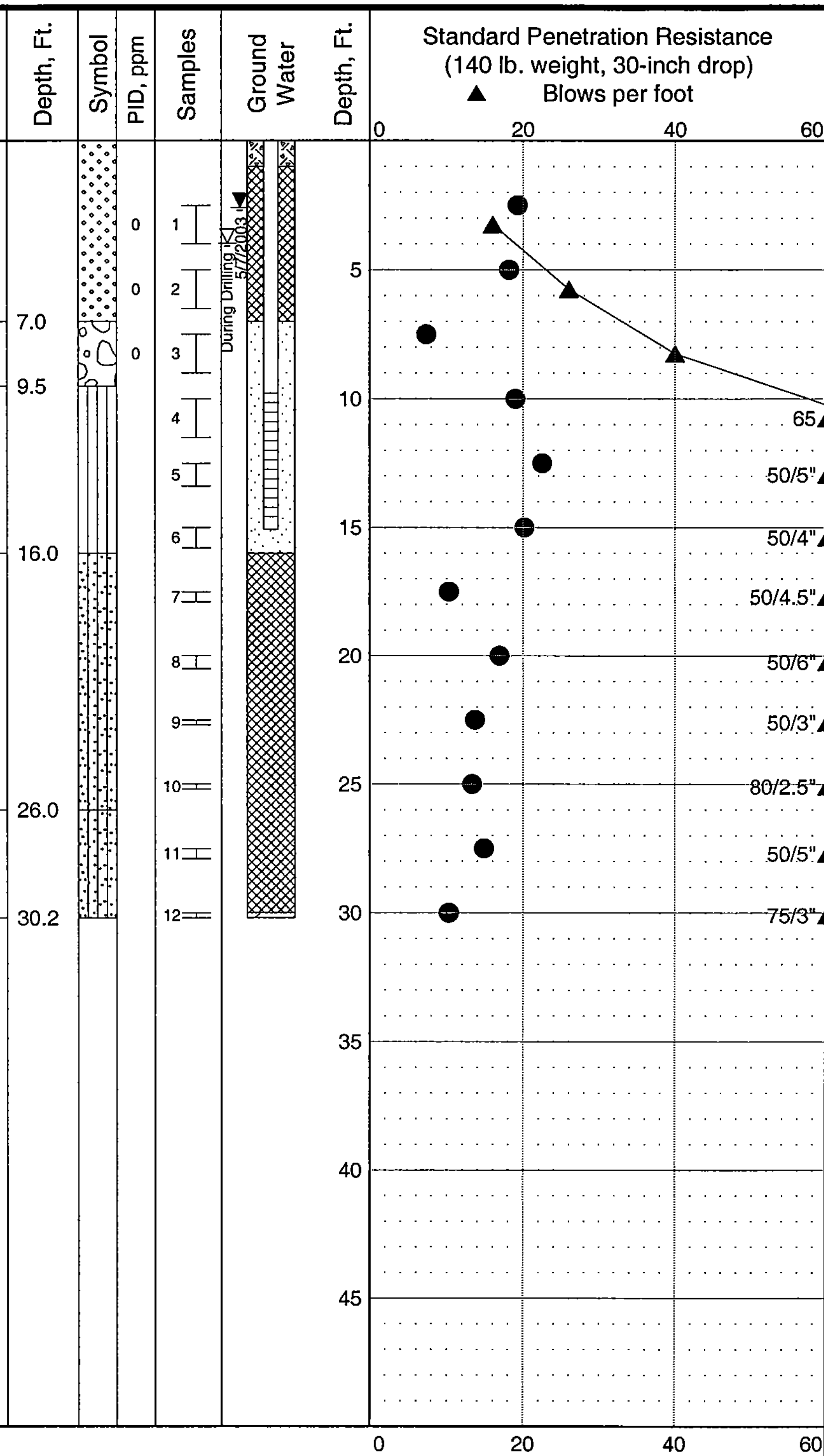
Coordinates: N: 618,496 E: 1,646,877

Surface Elevation: 161.8 Ft. Datum: NAVD88

SOIL DESCRIPTION	Depth, Ft.
Medium dense, brown, slightly silty, gravelly, fine to coarse SAND; wet; (f) SW.	7.0
Dense, brown, slightly silty, sandy GRAVEL; wet; (f) GP.	9.5
Very dense, gray, fine sandy SILT; wet; (Qvrl) ML.	16.0
Very dense, gray, trace gravelly to gravelly, sandy SILT; moist to wet; layer of silty, fine to medium sand at 20 feet; (Qvd) SM. - observation during drilling: hard drilling from 20 to 30 feet	26.0
Very dense, gray, slightly gravelly, silty SAND; moist to wet; (Qvd) SM.	30.2

BOTTOM OF BORING
COMPLETED 4/4/2003

Note: Hollow-stem auger was used to 10 feet, and mud-rotary techniques were used for the remainder of the borehole.



LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level ATD
- Ground Water Level in Well

NOTES

1. The boring was performed using HSA and Rotary Combined drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

LOG OF BORING PB-6

July 2003 21-1-09869-001

SHANNON & WILSON, INC.
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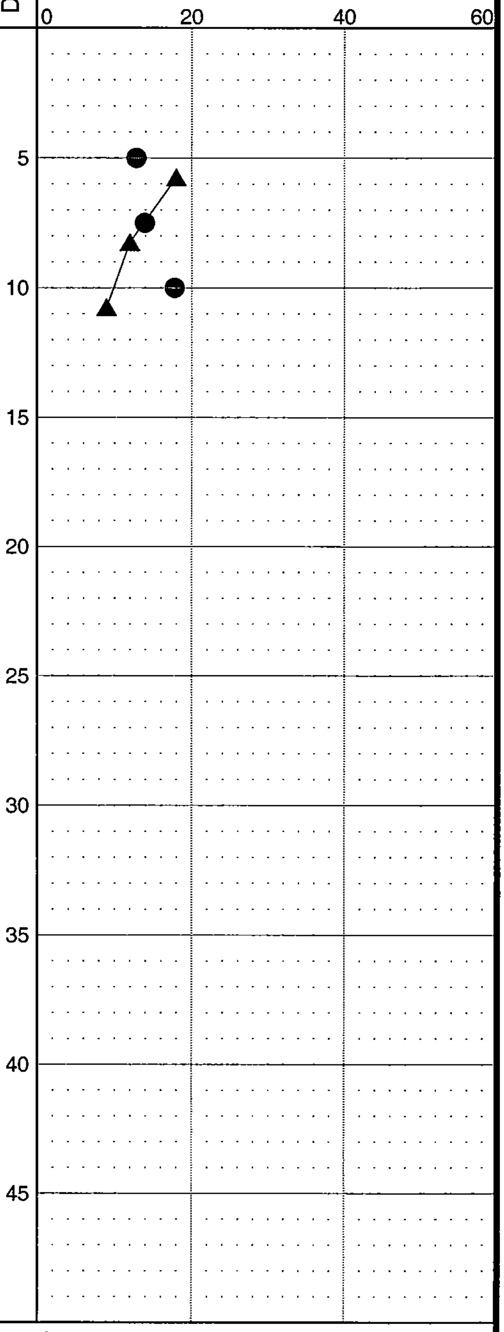
FIG. A-5

MASTER_LOG2 21-09869.GPJ SHAN_WIL.GDT 7/16/03 Log: XHL Rev: CLBM Typ: LKD

SOIL DESCRIPTION Coordinates: N: 618,483 E: 1,647,329 Surface Elevation: 213.6 Ft. Datum: NAVD88	Depth, Ft.	Symbol	PID, ppm	Samples	Ground Water
Crushed rock (3-inch minus) mixed with large rock up to 8 inches in diameter; (f) GP.	2.0				None Encountered During Drilling
Loose to medium dense, brown, slightly gravelly to gravelly, silty SAND; moist; scattered organics and wood debris; (f) SM. - observation during drilling: numerous wood fragments in cuttings			6 2.5	1 2	
BOTTOM OF BORING COMPLETED 4/2/2003	10.0		0	3	

Note: Hole was abandoned at 10 feet. Hollow-stem auger could not be kept straight due to large rocks near surface. Hole was moved 4 feet east and drilled as boring PB-7B.

Standard Penetration Resistance
(140 lb. weight, 30-inch drop)
▲ Blows per foot



● % Water Content

Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
Ｉ Standard Penetration Test

NOTES

1. The boring was performed using HSA and Rotary Combined drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

LOG OF BORING PB-7A

July 2003 21-1-09869-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-6

SOIL DESCRIPTION

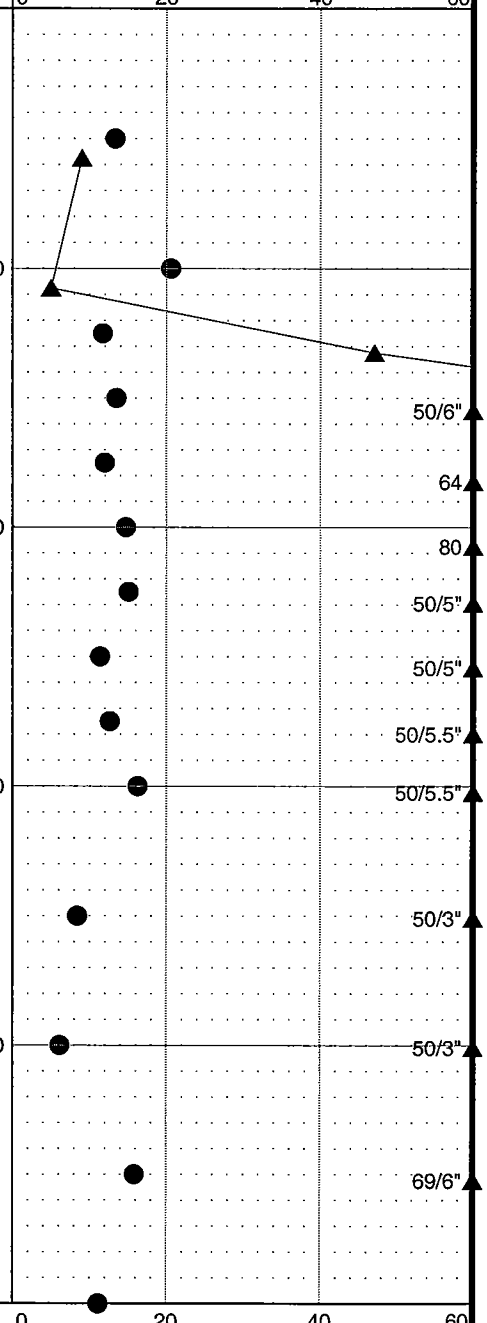
Coordinates: N: 618,483 E: 1,647,329
Surface Elevation: 213.6 Ft. Datum: NAVD88

Soil Description	Depth, Ft.	PID, ppm	Samples
Three-inch minus crushed rock mixed with cobbles 4 to 8 inches in diameter; (f) GP.	2.0		
Loose, orange-brown, gravelly, silty SAND; moist; scattered organics and wood debris; (f) SM.	12.0	7 0	1 2
Very dense, light brown, trace to slightly gravelly, silty SAND, trace of clay; moist; iron-oxide stains to 14 feet; with occasional layers of fine sandy silt, usually stratified; (Qvd) SM. - observation during drilling: easy to moderate drilling from 12 to 33 feet - becomes gray at 30 feet	33.0	0	3 4 5 6 7 8 9 10
Very dense, gray, trace to slightly gravelly, silty SAND; moist to wet; (Qvt) SM. - observation during drilling: rough drilling at 33 feet; moderate drilling from 40 to 70 feet - layer of silty, fine to medium sand, trace of gravel at 45 feet			11 12 13

Ground Water: 5/7/2003; 5/7/2003; None Encountered During Drilling

CONTINUED NEXT SHEET

Standard Penetration Resistance
(140 lb. weight, 30-inch drop)
▲ Blows per foot



LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level in Well
- Ground Water Level in VWP

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. The boring was performed using HSA and Rotary Combined drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

LOG OF BORING PB-7B

July 2003 21-1-09869-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-7
Sheet 1 of 2

MASTER_LOG2 21-09869.GPJ SHAN_WIL.GDT 7/16/03 Log: XHL Rev: CLBM Typ: LKD

SOIL DESCRIPTION

Coordinates: N: 618,483 E: 1,647,329

Surface Elevation: 213.6 Ft. Datum: NAVD88

Very dense, gray, trace to slightly gravelly, silty SAND; (Qvt) SM (cont.).

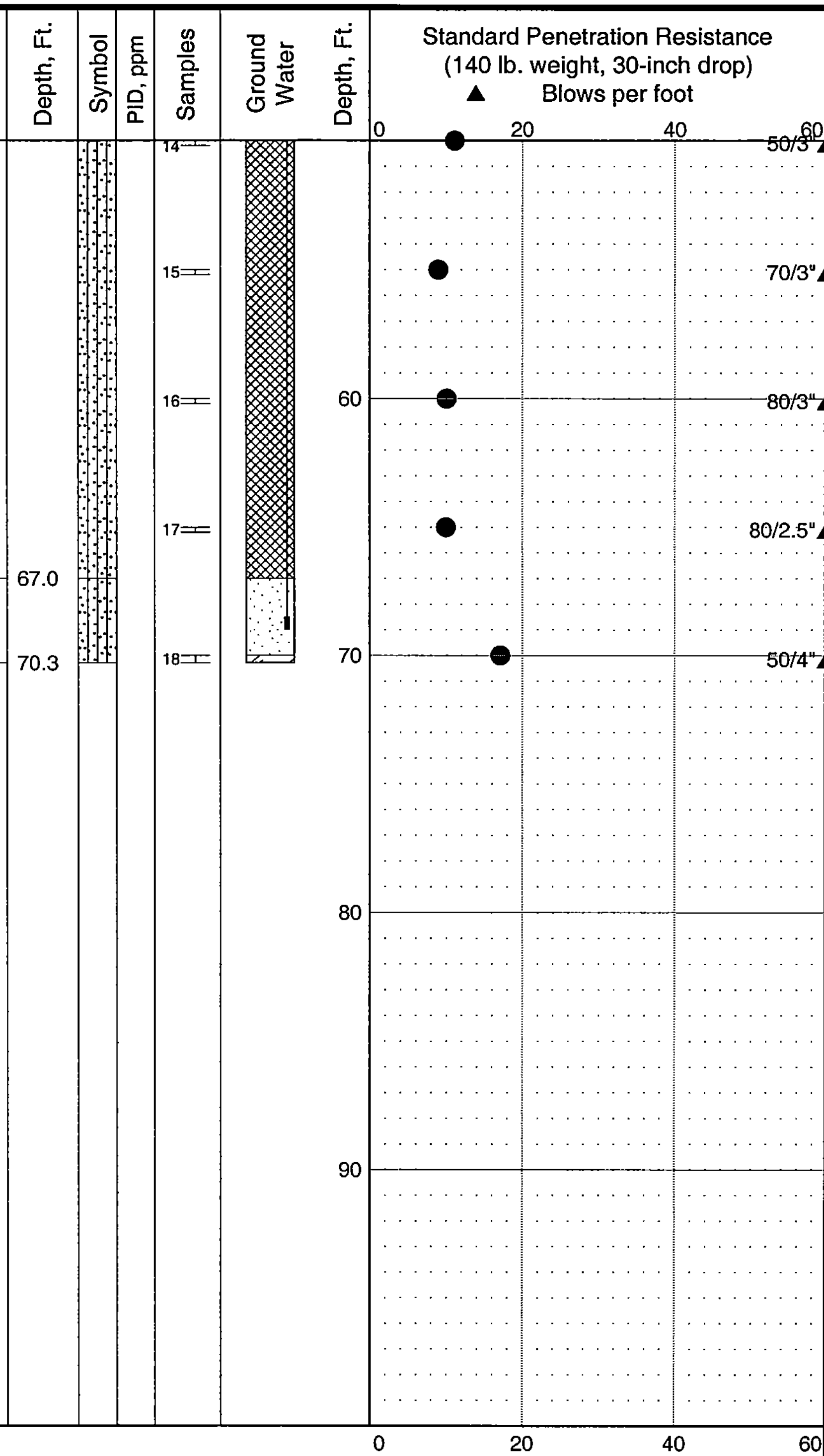
67.0

Very dense, gray, silty, fine to medium SAND; wet; (Qpgo) SM.

70.3

BOTTOM OF BORING
COMPLETED 4/3/2003

Notes:
1. Hollow-stem auger was used to 10 feet, and mud-rotary techniques were used for the remainder of the borehole.
2. Boring PB-7B is 4 feet east of boring PB-7A.



% Water Content

Plastic Limit ├──●──┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered	Piezometer Screen and Sand Filter
Standard Penetration Test	Bentonite-Cement Grout
	Bentonite Chips/Pellets
	Bentonite Grout
	Ground Water Level in Well
	Ground Water Level in VWP

NOTES

1. The boring was performed using HSA and Rotary Combined drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

LOG OF BORING PB-7B

July 2003 21-1-09869-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-7
Sheet 2 of 2

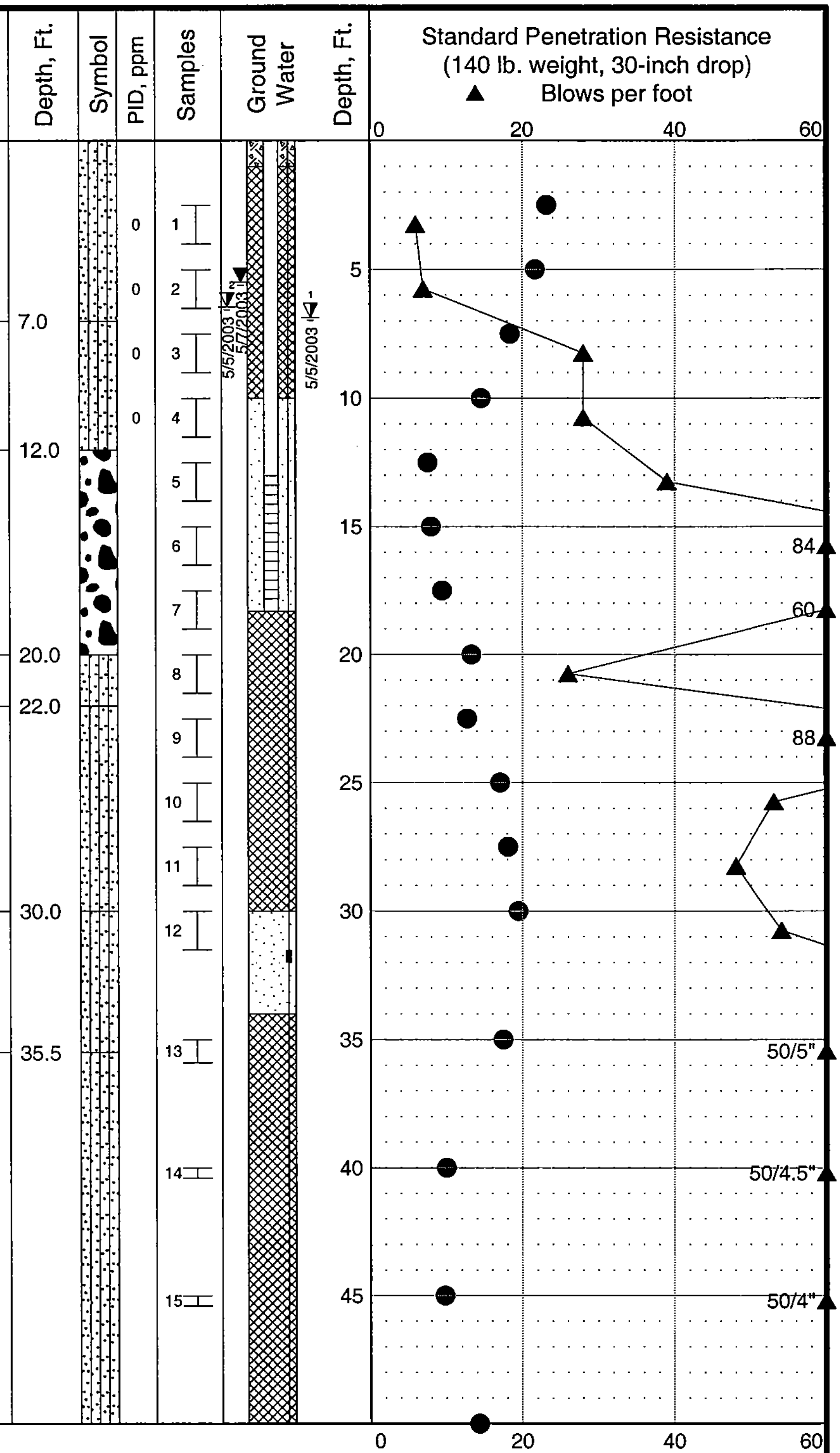
SOIL DESCRIPTION

Coordinates: N: 617,399 E: 1,647,383

Surface Elevation: 201.88 Ft. Datum: NAVD88

Depth, Ft.	Soil Description
	Loose, dark brown to brown, slightly gravelly, silty, fine to medium SAND; moist; scattered roots and organics; (f) SM.
7.0	Medium dense, brown-gray, gravelly, silty, fine to medium SAND; wet; scattered iron oxide stains, locally stratified; (Qvro) SM.
12.0	Dense to very dense, brown to light brown, slightly silty, sandy GRAVEL; moist to wet; scattered cobbles; (Qvro) GW. - observation during drilling: cobbles at 17 feet
20.0	Medium dense, brown to gray, slightly clayey, gravelly, silty SAND; moist; (Qvi) SM.
22.0	Very dense, light brown, slightly silty to silty, trace gravelly to gravelly, fine to coarse SAND; wet; occasional iron oxide stains; (Qvro) SM/SP. - observation during drilling: smooth drilling from 20 to 35.5 feet
30.0	Very dense, brown-gray, silty, fine to medium SAND; wet; (Qvro) SM.
35.5	Very dense, gray, slightly gravelly, silty SAND, moist; scattered slightly silty sand layers; (Qvd) SM. - observation during drilling: hard and rough drilling from 45 to 65 feet; very rough drilling and possible cobbles at 48 feet; easier drilling from 65 to 75 feet

CONTINUED NEXT SHEET



LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level in Well
- Ground Water Level in VWP

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

Natural Water Content

NOTES

1. The boring was performed using HSA and Rotary Combined drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

LOG OF BORING PB-10

July 2003 21-1-09869-001

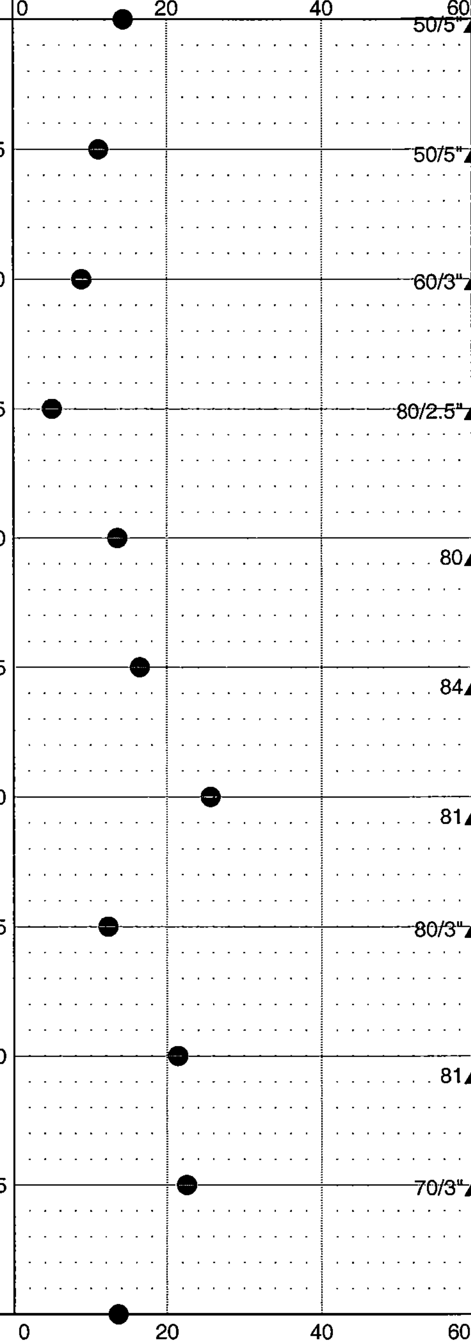
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-8
Sheet 1 of 3

Log: XHL Rev: CLBM Typ: EET

MASTER_LOG2 21-09869.GPJ SHAN_WIL.GDT 7/16/03

SOIL DESCRIPTION Coordinates: N: 617,399 E: 1,647,383 Surface Elevation: 201.88 Ft. Datum: NAVD88	Depth, Ft.	Symbol	PID, ppm	Samples	Ground Water	Depth, Ft.	Standard Penetration Resistance (140 lb. weight, 30-inch drop) ▲ Blows per foot
Very dense, gray, slightly gravelly, silty SAND; (Qvd) SM (cont.).				16			50/5"
				17		55	50/5"
				18		60	60/3"
				19		65	80/2.5"
				20		70	80
Very dense, gray, silty fine SAND to fine sandy SILT interbedded with hard, gray, fine sandy SILT; scattered organics; (Qvlc) SM/ML. - observation during drilling: easy drilling from 75 to 84 feet	73.0			21		75	84
				22		80	81
Very dense, gray, silty, gravelly SAND; moist; (Qvd) SM. - observation during drilling: rough drilling at 84 feet	84.0			23		85	80/3"
Very dense, gray, slightly gravelly, silty, fine to medium SAND; wet; silt layers, trace organics; (Qva/Qpnf?) SM.	89.0			24		90	81
				25		95	70/3"



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level in Well
- Ground Water Level in VWP

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. The boring was performed using HSA and Rotary Combined drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

LOG OF BORING PB-10

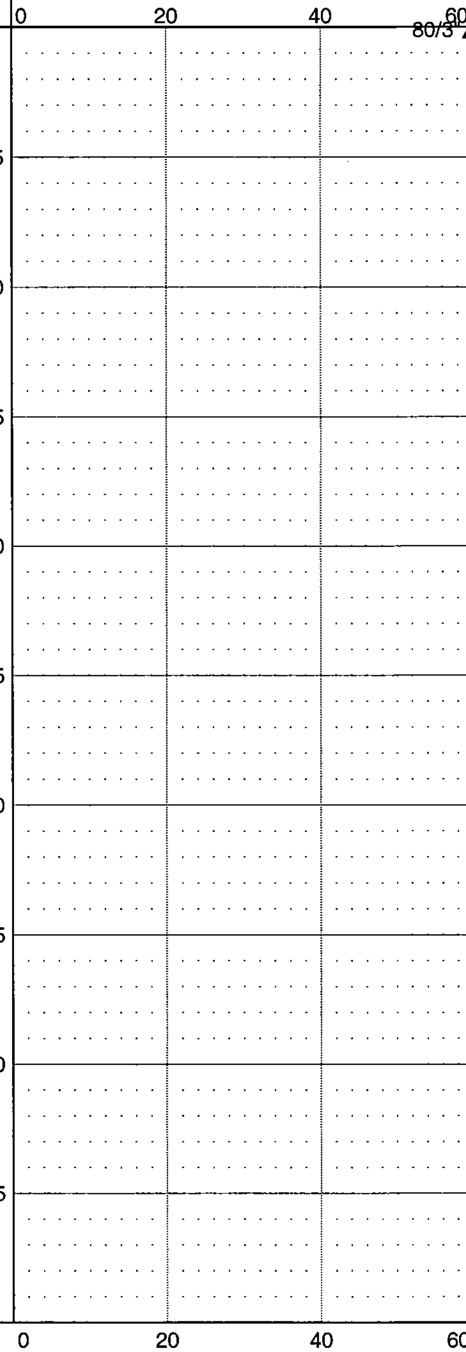
July 2003 21-1-09869-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-8
Sheet 2 of 3

SOIL DESCRIPTION Coordinates: N: 617,399 E: 1,647,383 Surface Elevation: 201.88 Ft. Datum: NAVD88	Depth, Ft.	Symbol	PID, ppm	Samples	Ground Water	Depth, Ft.
BOTTOM OF BORING COMPLETED 4/8/2003	100.2			26		
Note: Hollow-stem auger was used to 10 feet, and mud-rotary techniques were used for the remainder of the borehole						105 110 115 120 125 130 135 140 145

Standard Penetration Resistance
(140 lb. weight, 30-inch drop)
▲ Blows per foot



LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level in Well
- Ground Water Level in VWP

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. The boring was performed using HSA and Rotary Combined drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

LOG OF BORING PB-10

July 2003 21-1-09869-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-8
Sheet 3 of 3

Project: Brightwater Rt. 9 Project Location: IAA Parking Lot Contract Number:	**Log of Boring SB1** Sheet 1 of 5

Date(s) Drilled	11/14/01 - 11/15/01	Geotechnical Consultant	CH2M HILL	Logged By	T. Thomas/B. Wong	Checked By	T. Thomas
Drilling Method/ Rig Type	Mud Rotary/ Mobile B-59	Drilling Contractor	Geo-Tech Explorations, Inc.			Total Depth of Borehole	101.5 feet
Drill Bit Size/Type	NW Rods/tricone	Hammer Weight/Drop (lbs/in.)	140/30 Auto			Ground Surface Elevation/Datum	163.98 feet /
Location	SE of IAA Parking Lot	Coordinates	N 617418.6 E 1646818.0			Elevation Source	Survey

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	0						GP	Crushed rock/gravel surfacing 6"-1' thick (FILL).				
							SP-SM	Loose to medium dense, brown-gray w/ occasional FeO staining to gray, moist to wet, silty, gravelly, SAND, trace organics in upper 3', trace weathered rock inclusions, poorly graded sand, 1" minus gravel, interbedded SILTY SAND, and POORLY GRADED SAND WITH SILT AND GRAVEL, layers. Qvrf				
	2		1	2-4-5 (9)	80						18.6	
160	4											
	6		2	4-6-7 (13)	53			Moist to wet at 5'			13.7	
	8		3	6-8-6 (14)	67			Wet from 7.5'.			18.1	Recovery adequate but not recorded
155	10		4	7-9-11 (20)	67			Trace to 5% gravel in samples above 10'. Increasing gravel with depth below.			5.9	Pushed rock - 1-1/2" diameter broken rock in tip Recovery adequate but not recorded
	12		5	10-13-13 (26)	33					SA	10.5	Driller reports sand at 13.5'
150	14											
	16		6	9-8-7 (15)	67			Gray, with interbedded POORLY GRADED GRAVEL layers @ 15'.			16.2	Recovery adequate but not recorded
	18		7	11-13-14 (27)	100		ML	Very stiff, gray, wet, sandy SILT, trace clay. Qvrf		SA	22.7	
145	20											

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FIG. A-9

Project: Brightwater Rt. 9	Log of Boring SB1
Project Location: IAA Parking Lot	Sheet 2 of 5
Contract Number:	

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Blows / 6 in. (N)	Samples: Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	20		8	23-21-20 (41)	93		SM	Dense to very dense, gray, wet, silty SAND, trace to minor gravel, poorly graded fine to medium grained sand, fines content varies, gravel content varies. Qvd			11.9	
	22											
140	24											
			9	14-14-17 (31)	100					SA	16.2	
	26											
	28											
135												Driller reports hard drilling at 29'
	30		10	21-31-37 (68)	87						16.2	
	32											
130	34											
			11	28-37-38 (75)	80					SA	16.0	
	36											
	38											Driller reports hard drilling at 38'
125												
	40		12	47-50/6" (50/6")	100			Gravelly @ 40'.			13.3	
	42											

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FIG. A-9

Project: Brightwater Rt. 9 Project Location: IAA Parking Lot Contract Number:	Log of Boring SB1 Sheet 3 of 5

Elevation, feet	Depth, feet	SAMPLES: Type	SAMPLES: Number	SAMPLES: Blows / 6 in. (N)	SAMPLES: Recovery, %	SAMPLES: Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
-120	44											
	45		13	50/3.5" (50/3.5")	100			Siltier and gravelly @ 45'.			15.9	
	46											
	48											Driller reports gravel layer at 48'
-115												
	50		14	50/5" (50/5")	100			Gravelly, with trace clay @ 50'.			8.6	
	52						CL	Interbedded, hard to very dense, green-gray to gray, moist, silty, sandy, LEAN CLAY, trace organics, low plasticity, fine grained sand, with interlayers of CLAYEY SAND, POORLY GRADED SAND, SANDY SILT, and SILTY SAND, wood fragments throughout. Qvlc?				Driller reports clayey materia at 51.5' Driller reports sand layer between 53' and 53.5'
-110	54											
	56		15	12-19-23 (42)	100					AL	59.5	
	58											
-105												
	60		16	12-23-37 (60)	111			Sandy SILT with wood in 2 layers @ 60'-61.5'.			14.0	
	62											Driller reports becoming more sandy at 62.5'
-100	64											
	66		17	22-19-24 (43)	100			Top 4" of sample is medium to coarse grained POORLY GRADED SAND at 65'. Bottom 12" is clayey silty SAND with trace organics, wood chips			26.9	

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FIG. A-9

Project: Brightwater Rt. 9
Project Location: IAA Parking Lot
Contract Number:

Log of Boring SB1

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Blows / 6 in. (N)	Samples: Recovery, %	Samples: Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	68											Driller reports more sandy at 67'
-95												
	70		18	13-21-32 (53)	100			Moist to wet, silty SAND with fine grained sand.		SA	23.7	
	72											Driller reports clayey material from 72' to 72.5', sand at 73' and into very dense material at 73.5'
-90	74						SM	Very dense, gray, moist to wet, silty SAND, trace gravel, wood fragments. Qpgd ?				
	76		19	44-50/5" (50/5")	75					P200	13.9	
	78											
-85												
	80		20	23-29-34 (63)	100		SM	Dense to very dense, dark gray, moist, silty SAND, fine grained sand. Trace gravel @ 80'. Qpnf ?		P200	23.3	Driller reports going from dense to less dense material at 79.5'
	82											
-80	84											
	86		21	21-26-31 (57)	100					SA	24.7	
	88											
-75	90											

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Project: Brightwater Rt. 9
Project Location: IAA Parking Lot
Contract Number:

Log of Boring SB1

Elevation, feet	Depth, feet	SAMPLES: Type	SAMPLES: Number	SAMPLES: Blows / 6 in. (N)	SAMPLES: Recovery, %	SAMPLES: Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	90		22	34-50/6 (50/6")	33			Slighty moist to dry at 90'.			20.0	
	92											
-70	94											
	96		23	29 - 29 - 43 (72)	100			Moist to slightly moist at 95'. Trace gravel @ 95'.			27.7	
	98											Driller reports clay seams and back to sand at 97.5', and from 98' to 98.5'
-65												
	100		24	23 - 31 - 44 (75)	89			Slightly moist at 100'.		P200	22.9	
								Bottom of boring 101.5'				
	102											
-60	104											
	106											
	108											
-55												
	110											
	112											

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FIG. A-9

Project: Brightwater Rt. 9	Log of Boring SB2
Project Location: IAA Parking Lot	Sheet 1 of 3
Contract Number:	

Date(s) Drilled	11/19/01 - 11/19/01	Geotechnical Consultant	CH2M HILL	Logged By	B. Wong	Checked By	T. Thomas
Drilling Method/ Rig Type	Mud Rotary/ Mobile B-59	Drilling Contractor	Geo-Tech Explorations, Inc.	Total Depth of Borehole	60.3 feet		
Drill Bit Size/Type	NW Rods/tricone	Hammer Weight/Drop (lbs/in.)	140/30 Auto	Ground Surface Elevation/Datum	166.81 feet /		
Location	Fitz Auto Junk Yard	Coordinates	N 617934.6 E 1646977.4	Elevation Source	Survey		

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Blows / 6 in. (N)	Samples: Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	0							Crushed rock/gravel surfacing.				
-165	2						SM	Medium dense to very dense, brown-gray to gray, wet to slightly moist, silty SAND, trace gravel, poorly graded fine to medium grained sand, grades dryer and more dense with depth. Qvrf				Driller reports silty sand at 2.5'
	4											
	6		1	7-9-9 (18)	89			Dense, gray, wet @ 5'.		SA	15.8	Driller reports sandy silt from 5.5' to 9'
-160	8											
	10		2	5-16-27 (43)	200			Very dense, gray, moist to wet, w/ sandier lenses @ 10'.			12.4	
-155	12											
	14											
	16		3	15-33-50 (83)	78			Dry to slightly moist at 15'.		P200	11.3	
-150							SM	Very dense, gray, moist to slightly moist, silty SAND to sandy SILT, trace gravel, poorly graded sand, with interbeds of siltier and cleaner sand. Qvd				Driller reports gravel layers at 16'
	18											
	20											

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FIG. A-10
Sheet 1 of 3

Project: Brightwater Rt. 9 Project Location: IAA Parking Lot Contract Number:	**Log of Boring SB2** Sheet 2 of 3

Elevation, feet	Depth, feet	Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	20		4	25-50/4" (50/4")	58			Slightly moist at 20'.			11.6	
-145	22											
	24		5	35-50/3" (50/3")	42			Hard, moist to slightly moist, sandy SILT, fine grained sand.		P200	13.9	
-140	26											
	28											
	30		6	35-50/4.5" (50/4.5")	67			Hard, gray, wet (sand) to slightly moist (silt), sandy SILT interbeds in wet, poorly graded SAND with silt matrix @ 30'.			15.5	No recovery in sampler tip - gravel
-135	32											
	34		7	49-50/3" (50/3")	75			Predominately slightly moist to moist, fine grained silty SAND with medium grained sand interbeds @ 35'.			12.2	
-130	36											
	38											
	40		8	50/6" (50/6")	100			Moist at 40'.		P200	13.8	
-125	42											

FIG. A-10
Sheet 2 of 3

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Project: Brightwater Rt. 9
Project Location: IAA Parking Lot
Contract Number:

Log of Boring SB2

Sheet 3 of 3

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	USCS	MATERIAL DESCRIPTION	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	44									
	45	◣	9	50/4.5" (50/4.5")	71		Slightly moist to dry @ 45'.		11.9	
	46					SM	Very dense, moist to wet, gravelly silty SAND, well graded sand, trace clay layers. Qvt			Driller reports gravel seam at 46'
120	46.5									Driller reports clay layer at 46.5' to 47'
	48									
	50	◣	10	50/5" (50/5")	63		Wet @ 50'.	SA	9.1	Driller reports silty gravelly sand from 49.5' to 50'
115	52									Driller reports gravel seam at 51.5'
	54									Driller reports going from gravelly to finer material at 53.5'
	55	◣	11	50/4" (50/4")	76		Moist, with layers of siltier and sandier material, 1" diameter weathered rock inclusion @ 55'.		9.2	
	56									
110	58									
	60	◣	12	50/3" (50/3")	67		Moist, trace clay @ 60'. Bottom of boring 60.3'		9.3	
105	62									
	64									
	66									

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FIG. A-10
Sheet 3 of 3

Project: Brightwater Rt. 9 Project Location: IAA Parking Lot Contract Number:	**Log of Boring SB3** Sheet 1 of 3

Date(s) Drilled	11/12/01 - 11/12/01	Geotechnical Consultant	CH2M HILL	Logged By	T. Thomas	Checked By	T. Thomas
Drilling Method/ Rig Type	Mud Rotary/ Mobile B-59	Drilling Contractor	Geo-Tech Explorations, Inc.	Total Depth of Borehole	51.4 feet		
Drill Bit Size/Type	NW Rods/tricone	Hammer Weight/Drop (lbs/in.)	140/30 Auto	Ground Surface Elevation/Datum	210.79 feet /		
Location	NE Corner INS Auto Auction Lot	Coordinates	N 618256.7 E 1647526.2	Elevation Source	Survey		

Elevation, feet	Depth, feet	Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	0							Gravel surfacing (FILL).				
210												
	2						SM	Medium dense to dense, gray to tan with some iron oxide stained pockets, moist to wet, silty, occasionally gravelly, SAND to sandy SILT, poorly graded sand, interbedded fine grained sand and medium to coarse graded sand, 1" minus gravel, interlayered sandier and siltier material throughout. Qvrf				
	4											
								Wet at 5'.			15.0	Driller letting hammer down with winch. Could be too much weight.
205	6		1	11-8-4 (12)	60							
	8											
	10							Tan-gray, @10'.		P200	12.5	Hammer stops when out or range of seat, ~ every 5 blows. Driller letting winch out.
200			2	12-11-16 (27)	80			Olive, @10.6'.		P200	19.4	
	12											
			3	11-13-19 (32)	67			Dense, gray, predominately medium grained sand, estimated less than 10% gravel @ 12.5'.			9.9	Asked for extra sample at 12.5' to get hammer worked out. Still winching hammer for this sample. 1-½" diameter broken rock jammed in tip. Drilling harder from 12.5' to 15'
	14											
195	16		4	11-14-19 (33)	67			1" to ½" thick interbeds of fine grained silty SAND, and sandy SILT, with medium grained, poorly graded SAND layers, 1" minus gravel scattered throughout @ 15'			15.1	Got hammer cage to release. Preliminary energy measurements "pretty consistent around 80%" from Burt Minor.
	18											
	20											

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FIG. A-11

Sheet 1 of 3

Project: Brightwater Rt. 9	Log of Boring SB3
Project Location: IAA Parking Lot	Sheet 2 of 3
Contract Number:	

Elevation, feet	Depth, feet	Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
-190	20		5	30-50/3.5" (50/3.5")	70		ML	Hard to very dense, gray, slightly moist to wet, sandy SILT to silty SAND, trace weathered gravel, well to poorly graded sand, moisture increasing with depth, slightly moist at 20'. Qvd			9.4	Possible aquitard Hard drilling to 25'
-185	25		6	56/5.5" (56/5.5")	50			Moist, silty SAND with ~3/16" diameter inclusion of highly weathered gravel @ 25'.			8.6	Energy measurement on automatic hammer
	28		7	100/5" (100/5")	40					P200 AL	10.0	Energy measurement on cathead & manual hammer requested by driller
-180	30		8	35-50/3" (50/3")	50			Interlayered sandy SILT and silty SAND with 2 - ½" thick medium grained sand layers @ 30'.			14.1	Sampler stopped penetrating at 7"
	31						SM	Very dense, dry to wet, silty gravelly SAND, predominately fine grained sand Qvt				
-175	35		9	50/4" (50/4")	91			Dry @ 35'.			9.8	
-170	40		10	50/4" (50/4")	30			Dry at 40'.		SA	8.0	

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FIG. A-11
Sheet 2 of 3

Project: Brightwater Rt. 9 **Project Location:** IAA Parking Lot **Contract Number:**	**Log of Boring SB3** Sheet 3 of 3

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	44											Hard drilling.
-165	46		11	31-50/4" (50/4")	60						24.6	Gravel in hole closed around bit at ~35' causing difficulty pulling rods for sampling
	48											Driller reports 48' to 50' drilled more like clay with scattered gravel, clay chunks in cuttings
-160	50		12	14-35-50/4.5" (85/10.5")	100			Clayier SILT from 50' to 51'.		P200	14.1	
								Looser and wet ½" thick zone @ 51' above silty gravelly SAND, predominately medium and coarse grained, ¾" minus gravel.			14.0	
	52							Bottom of boring 51.4'				
	54											
-155	56											
	58											
-150	60											
	62											
	64											
-145	66											

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FIG. A-11

Project: Brightwater Rt. 9 **Project Location:** IAA Parking Lot **Contract Number:**	# Log of Boring SB4 Sheet 1 of 3

Date(s) Drilled: 11/10/01 - 11/10/01	Geotechnical Consultant: CH2M HILL	Logged By: B. Wong	Checked By: T. Thomas
Drilling Method/ Rig Type: Mud Rotary/ Mobile B-59	Drilling Contractor: Geo-Tech Explorations, Inc.		Total Depth of Borehole: 50.4 feet
Drill Bit Size/Type: NW Rods/tricone	Hammer Weight/Drop (lbs/in.): 140/30 Auto		Ground Surface Elevation/Datum: 166.75 feet /
Location: Mustang Ranch	Coordinates: N 618746.5 E 1646814.9		Elevation Source: Survey

Elevation, feet	Depth, feet	Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	0						SP-SM	Medium dense to dense, brown, wet, trace gravel to gravelly, slightly silty SAND, fine to coarse grained sand (FILL?) Qvrf ?				
165	2											Driller reports big gravel layer from 2' to 3'
	4											
	6		1	6 - 6 - 9 (15)	33						12.5	
160	8											Driller reports gravel layer at 8'
	10		2	13-13-18 (31)	22					SA	7.9	
155	12											
	13						ML	Hard, gray, wet to slightly moist, sandy SILT, poorly graded medium to fine grained sand, trace to some gravel. Qvlc ?				Driller reports drilling more sandy from 13' to 14'
	14											
	16		3	15-28-36 (64)	78			Fewer fines in top 8" of sample, wet, borderline silty SAND @ 15'.			20.7	
150	18											
	20											

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Project: Brightwater Rt. 9 Project Location: IAA Parking Lot Contract Number:	Log of Boring SB4 Sheet 2 of 3

Elevation, feet	Depth, feet	Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	20		4	50/6" (50/6")	67			Slightly moist at 20'.		P200 AL	12.2	
-145	22											
	24											
			5	50/5" (50/5")	74			Slightly moist at 25'. Trace gravel.		P200	14.1	
	26											
-140	28											
	30		6	50/5.5" (50/5.5")	30			Moist at 30'. Estimated 30% fine (1/4" to ½" diameter) gravel @ 30'.			7.7	
												Change to 4-5/8" bit at 31'
-135	32											Driller reports very hard drilling from 32' to 34'.
												Driller reports sand from 33' to 34'
	34											
			7	30-50/6" (50/6")	100		SM	Very dense, gray, moist, gravelly, silty SAND, well to poorly graded sand. Qpgd ?		P200	20.0	Drilling gravel lenses from 35.5' to 36'
-130	36											
	38											
	40		8	50/6" (50/6")	50			Estimated 20% to 40% gravel @ 40'.			9.1	
-125	42											Driller reports gravel lenses from 41' to 43'

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FIG. A-12
Sheet 2 of 3

Project: Brightwater Rt. 9 Project Location: IAA Parking Lot Contract Number:	**Log of Boring SB4** Sheet 3 of 3

Elevation, feet	Depth, feet	Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	44											
			9	50/4.5" (50/4.5")	90			Predominately fine grained sand.		SA	7.3	Driller reports gravel lenses at 44.5'
	46											
120												
	48											Driller reports gravel lenses at 48'
	50		10	50/5" (50/5")	83			Predominately fine grained sand. Bottom of boring 50.4'		SA	8.0	
115	52											
	54											
	56											
110												
	58											
	60											
105	62											
	64											
	66											

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FIG. A-12
Sheet 3 of 3

Project: Brightwater Rt. 9 Project Location: IAA Parking Lot Contract Number:	**Log of Boring SB5** Sheet 1 of 3

Date(s) Drilled	11/15/01 - 11/15/01	Geotechnical Consultant	CH2M HILL	Logged By B. Wong	Checked By T. Thomas
Drilling Method/ Rig Type	Mud Rotary/ Mobile B-59	Drilling Contractor	Geo-Tech Explorations, Inc.	Total Depth of Borehole	50.6 feet
Drill Bit Size/Type	NW Rods/tricone	Hammer Weight/Drop (lbs/in.)	140/30 Auto	Ground Surface Elevation/Datum	220.85 feet /
Location	Evergreen Utilities Yard	Coordinates	N 618778.3 E 1647461.7	Elevation Source	Survey

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	0						SM	Dense to very dense, hard, brownish gray to gray, moist, gravelly silty SAND to gravelly sandy SILT, predominately fine grained sand Qvd				
220												
	2											Driller reports silty sand to gravel
	4											
215	6		1	14-17-19 (36)	78					P200 AL	8.0	
	8											Driller reports gravel layer at 7' Driller reports silty sand from 8' to 9' Driller reports gravel layer at 9'
	10										13.0	
210			2	13-23-49 (72)	89							
	12											
	14											
205	16		3	18-46-50 (96)	78					SA AL	11.4	
	18											Gravel layer at 18'
	20											

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Project: Brightwater Rt. 9 Project Location: IAA Parking Lot Contract Number:	**Log of Boring SB5** Sheet 2 of 3

Elevation, feet	Depth, feet	SAMPLES: Type	SAMPLES: Number	SAMPLES: Blows / 6 in. (N)	SAMPLES: Recovery, %	SAMPLES: Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
200	20		4	37-50-50 (100)	83			Moist to wet at 20'.		P200	10.6	
	22											
	24											
195	26		5	42-50/5" (50/5")	100					P200	10.3	
	28											
190	30		6	23-37-50/4" (87/10")	78					P200	14.3	
	32											
	34											
185	36		7	50/6" (50/6")	83						10.6	
	38											
180	40		8	50/5" (50/5")	74					P200	11.9	
	42											

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FIG. A-13

Project: Brightwater Rt. 9	Log of Boring SB5
Project Location: IAA Parking Lot	Sheet 3 of 3
Contract Number:	

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	44											
			9	50/4" (50/4")	76						9.1	
-175	46											Driller reports gravel layer from 46' to 48.5'. Large gravels
	48											
	50		10	43-50/1" (50/1")	42			Slightly moist, sandy gravelly SILT @ 50'.		SA AL	12.6	
-170								Bottom of boring 50.6'				
	52											
	54											
-165	56											
	58											
	60											
-160												
	62											
	64											
-155	66											

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FIG. A-13
Sheet 3 of 3

Project: Brightwater Rt. 9 Project Location: IAA Parking Lot Contract Number:	**Log of Boring SB2** Sheet 1 of 3

Date(s) Drilled	11/19/01 - 11/19/01	Geotechnical Consultant	CH2M HILL	Logged By	B. Wong	Checked By	T. Thomas
Drilling Method/ Rig Type	Mud Rotary/ Mobile B-59	Drilling Contractor	Geo-Tech Explorations, Inc.			Total Depth of Borehole	60.3 feet
Drill Bit Size/Type	NW Rods/tricone	Hammer Weight/Drop (lbs/in.)	140/30 Auto			Ground Surface Elevation/Datum	166.81 feet /
Location	Fitz Auto Junk Yard	Coordinates	N 617934.6	E 1646977.4		Elevation Source	Survey

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	0							Crushed rock/gravel surfacing.				
165	2						SM	Medium dense to very dense, brown-gray to gray, wet to slightly moist, silty SAND, trace gravel, poorly graded fine to medium grained sand, grades dryer and more dense with depth. (QVA)				Driller reports silty sand at 2.5'
	4											
	6		1	7-9-9 (18)	89			Dense, gray, wet @ 5'.		SA	15.8	Driller reports sandy silt from 5.5' to 9'
160	8											
	10		2	5-16-27 (43)	200			Very dense, gray, moist to wet, w/ sandier lenses @ 10'.			12.4	
155	12											
	14											
			3	15-33-50 (83)	78			Dry to slightly moist at 15'.		P200	11.3	
	16						SM	Very dense, gray, moist to slightly moist, silty SAND to sandy SILT, trace gravel, poorly graded sand, with interbeds of siltier and cleaner sand. (QVA)				Driller reports gravel layers at 16'
150	18											
	20											

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FIG. A-10

Project: Brightwater Rt. 9 Project Location: IAA Parking Lot Contract Number:	Log of Boring SB2 Sheet 2 of 3

Elevation, feet	Depth, feet	Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	20		4	25-50/4" (50/4")	58			Slightly moist at 20'.			11.6	
145	22											
	24		5	35-50/3" (50/3")	42			Hard, moist to slightly moist, sandy SILT, fine grained sand.		P200	13.9	
140	26											
	28											
	30		6	35-50/4.5" (50/4.5")	67			Hard, gray, wet (sand) to slightly moist (silt), sandy SILT interbeds in wet, poorly graded SAND with silt matrix @ 30'.			15.5	No recovery in sampler tip - gravel
135	32											
	34		7	49-50/3" (50/3")	75			Predominately slightly moist to moist, fine grained silty SAND with medium grained sand interbeds @ 35'.			12.2	
130	36											
	38											
	40		8	50/6" (50/6")	100			Moist at 40'.		P200	13.8	
125	42											

Project: Brightwater Rt. 9
Project Location: IAA Parking Lot
Contract Number:

Log of Boring SB2

Sheet 3 of 3

Elevation, feet	Depth, feet	Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	44											
	45		9	50/4.5" (50/4.5")	71			Slightly moist to dry @ 45'.			11.9	
	46						SM	Very dense, moist to wet, gravelly silty SAND, well graded sand, trace clay layers. (QVA)				Driller reports gravel seam a 46' Driller reports clay layer at 46.5' to 47'
-120												
	48											
	50		10	50/5" (50/5")	63			Wet @ 50'.		SA	9.1	Driller reports silty gravelly sand from 49.5' to 50'
-115	52											Driller reports gravel seam a 51.5'
	54											Driller reports going from gravelly to finer material at 53.5'
	55		11	50/4" (50/4")	76			Moist, with layers of siltier and sandier material, 1" diameter weathered rock inclusion @ 55'.			9.2	
	56											
-110												
	58											
	60		12	50/3" (50/3")	67			Moist, trace clay @ 60'. Bottom of boring 60.3'			9.3	
-105	62											
	64											
	66											

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FIG. A-10
Sheet 3 of 3

Project: Brightwater Rt. 9 **Project Location:** IAA Parking Lot **Contract Number:**	# Log of Boring SB3 Sheet 1 of 3

Date(s) Drilled	11/12/01 - 11/12/01	Geotechnical Consultant	CH2M HILL	Logged By	T. Thomas	Checked By	T. Thomas
Drilling Method/ Rig Type	Mud Rotary/ Mobile B-59	Drilling Contractor	Geo-Tech Explorations, Inc.	Total Depth of Borehole	51.4 feet		
Drill Bit Size/Type	NW Rods/tricone	Hammer Weight/Drop (lbs/in.)	140/30 Auto	Ground Surface Elevation/Datum	210.79 feet /		
Location	NE Corner INS Auto Auction Lot	Coordinates	N 618256.7 E 1647526.2	Elevation Source	Survey		

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	0							Gravel surfacing (FILL).				
210												
	2						SM	Medium dense to dense, gray to tan with some iron oxide stained pockets, moist to wet, silty, occasionally gravelly, SAND to sandy SILT, poorly graded sand, interbedded fine grained sand and medium to coarse graded sand, 1" minus gravel, interlayered sandier and siltier material throughout. (QVA)				
	4											
205	6		1	11-8-4 (12)	60			Wet at 5'.			15.0	Driller letting hammer down with winch. Could be too much weight.
	8											
200	10		2	12-11-16 (27)	80			Tan-gray, @10'.		P200	12.5	Hammer stops when out of range of seat, ~ every 5 blows. Driller letting winch out.
								Olive, @10.6'.		P200	19.4	
	12		3	11-13-19 (32)	67			Dense, gray, predominately medium grained sand, estimated less than 10% gravel @ 12.5'.			9.9	Asked for extra sample at 12.5' to get hammer worked out. Still winching hammer for this sample. 1-½" diameter broken rock jammed in tip. Drilling harder from 12.5' to 15'
	14											
195	16		4	11-14-19 (33)	67			1" to ½" thick interbeds of fine grained silty SAND, and sandy SILT, with medium grained, poorly graded SAND layers, 1" minus gravel scattered throughout @ 15'			15.1	Got hammer cage to release. Preliminary energy measurements "pretty consistent around 80%" from Burt Minor.
	18											
	20											

Project: Brightwater Rt. 9 Project Location: IAA Parking Lot Contract Number:	Log of Boring SB3 Sheet 2 of 3

Elevation, feet	Depth, feet	SAMPLES: Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
-190	20		5	30-50/3.5" (50/3.5")	70		ML	Hard to very dense, gray, slightly moist to wet, sandy SILT to silty SAND, trace weathered gravel, well to poorly graded sand, moisture increasing with depth, slightly moist at 20'. (QVA)			9.4	Possible aquitard Hard drilling to 25'
-185	25		6	56/5.5" (56/5.5")	50			Moist, silty SAND with ~3/16" diameter inclusion of highly weathered gravel @ 25'.			8.6	Energy measurement on automatic hammer
	28		7	100/5" (100/5")	40					P200 AL	10.0	Energy measurement on cathead & manual hammer requested by driller
-180	30		8	35-50/3" (50/3")	50			Interlayered sandy SILT and silty SAND with 2 - ½" thick medium grained sand layers @ 30'.			14.1	Sampler stopped penetrating at 7"
	31						SM	Very dense, dry to wet, silty gravelly SAND, predominately fine grained sand (QVA)				
-175	35		9	50/4" (50/4")	91			Dry @ 35'.			9.8	
-170	40		10	50/4" (50/4")	30			Dry at 40'.		SA	8.0	

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Project: Brightwater Rt. 9 Project Location: IAA Parking Lot Contract Number:	Log of Boring SB3 Sheet 3 of 3

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	44											Hard drilling.
-165	46		11	31-50/4" (50/4")	60						24.6	Gravel in hole closed around bit at ~35' causing difficulty pulling rods for sampling
	48											Driller reports 48' to 50' drilled more like clay with scattered gravel, clay chunks in cuttings
	50							Clayier SILT from 50' to 51'.		P200	14.1	
-160			12	14-35-50/4.5" (85/10.5")	100			Looser and wet ½" thick zone @ 51' above silty gravelly SAND, predominately medium and coarse grained, ¾" minus gravel.			14.0	
	52							Bottom of boring 51.4'				
	54											
-155	56											
	58											
	60											
-150	62											
	64											
-145	66											

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Project: Brightwater Rt. 9 **Project Location:** IAA Parking Lot **Contract Number:**	# Log of Boring SB4 Sheet 1 of 3

Date(s) Drilled	11/10/01 - 11/10/01	Geotechnical Consultant	CH2M HILL	Logged By	B. Wong
Checked By	T. Thomas	Drilling Method/ Rig Type	Mud Rotary/ Mobile B-59	Drilling Contractor	Geo-Tech Explorations, Inc.
Total Depth of Borehole	50.4 feet	Drill Bit Size/Type	NW Rods/tricone	Hammer Weight/Drop (lbs/in.)	140/30 Auto
Ground Surface Elevation/Datum	166.75 feet /	Location	Mustang Ranch	Coordinates	N 618746.5 E 1646814.9
Elevation Source	Survey				

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	0						SP-SM	Medium dense to dense, brown, wet, trace gravel to gravelly, slightly silty SAND, fine to coarse grained sand (FILL?) (QVA)				
165	2											Driller reports big gravel layer from 2' to 3'
	4											
	6		1	6 - 6 - 9 (15)	33						12.5	
160	8											Driller reports gravel layer at 8'
	10		2	13-13-18 (31)	22					SA	7.9	
155	12											
	13						ML	Hard, gray, wet to slightly moist, sandy SILT, poorly graded medium to fine grained sand, trace to some gravel. (QVA)				Driller reports drilling more sandy from 13' to 14'
	14											
	15		3	15-28-36 (64)	78			Fewer fines in top 8" of sample, wet, borderline silty SAND @ 15'.			20.7	
150	16											
	18											
	20											

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FIG. A-12

Project: Brightwater Rt. 9
Project Location: IAA Parking Lot
Contract Number:

Log of Boring SB4

Elevation, feet	Depth, feet	Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	20		4	50/6" (50/6")	67			Slightly moist at 20'.		P200 AL	12.2	
-145	22											
	24											
			5	50/5" (50/5")	74			Slightly moist at 25'. Trace gravel.		P200	14.1	
-140	26											
	28											
	30		6	50/5.5" (50/5.5")	30			Moist at 30'. Estimated 30% fine (1/4" to ½" diameter) gravel @ 30'.			7.7	
												Change to 4-5/8" bit at 31'
-135	32											Driller reports very hard drilling from 32' to 34'.
												Driller reports sand from 33' to 34'
	34											
			7	30-50/6" (50/6")	100		SM	Very dense, gray, moist, gravelly, silty SAND, well to poorly graded sand. (QVA)		P200	20.0	Drilling gravel lenses from 35.5' to 36'
-130	36											
	38											
	40		8	50/6" (50/6")	50			Estimated 20% to 40% gravel @ 40'.			9.1	
-125	42											Driller reports gravel lenses from 41' to 43'

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FIG. A-12

Project: Brightwater Rt. 9	Log of Boring SB4
Project Location: IAA Parking Lot	Sheet 3 of 3
Contract Number:	

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	44											
	45		9	50/4.5" (50/4.5")	90			Predominately fine grained sand.		SA	7.3	Driller reports gravel lenses at 44.5'
120	46											
	48											Driller reports gravel lenses at 48'
	50		10	50/5" (50/5")	83			Predominately fine grained sand. Bottom of boring 50.4'		SA	8.0	
115	52											
	54											
110	56											
	58											
	60											
105	62											
	64											
	66											

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FIG. A-12

Project: Brightwater Rt. 9 Project Location: IAA Parking Lot Contract Number:	**Log of Boring SB5** Sheet 1 of 3

Date(s) Drilled	11/15/01 - 11/15/01	Geotechnical Consultant	CH2M HILL	Logged By	B. Wong	Checked By	T. Thomas
Drilling Method/ Rig Type	Mud Rotary/ Mobile B-59	Drilling Contractor	Geo-Tech Explorations, Inc.	Total Depth of Borehole	50.6 feet		
Drill Bit Size/Type	NW Rods/tricone	Hammer Weight/Drop (lbs/in.)	140/30 Auto	Ground Surface Elevation/Datum	220.85 feet /		
Location	Evergreen Utilities Yard	Coordinates	N 618778.3 E 1647461.7	Elevation Source	Survey		

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	0						SM	Dense to very dense, hard, brownish gray to gray, moist, gravelly silty SAND to gravelly sandy SILT, predominately fine grained sand (QVA)				
220												
	2											Driller reports silty sand to gravel
	4											
215	6		1	14-17-19 (36)	78					P200 AL	8.0	
												Driller reports gravel layer at 7'
	8											Driller reports silty sand from 8' to 9'
												Driller reports gravel layer at 9'
	10										13.0	
210			2	13-23-49 (72)	89							
	12											
	14											
205	16		3	18-46-50 (96)	78					SA AL	11.4	
	18											Gravel layer at 18'
	20											

FIG. A-13
Sheet 1 of 3

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Project: Brightwater Rt. 9
Project Location: IAA Parking Lot
Contract Number:

Log of Boring SB5

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	20		4	37-50-50 (100)	83			Moist to wet at 20'.		P200	10.6	
-200	22											
	24		5	42-50/5" (50/5")	100					P200	10.3	
-195	26											
	28											
	30		6	23-37-50/4" (87/10")	78					P200	14.3	
-190	32											
	34		7	50/6" (50/6")	83						10.6	
-185	36											
	38											
	40		8	50/5" (50/5")	74					P200	11.9	
-180	42											

Project: Brightwater Rt. 9
Project Location: IAA Parking Lot
Contract Number:

Log of Boring SB5

Sheet 3 of 3

Elevation, feet	Depth, feet	Samples: Type	Samples: Number	Samples: Blows / 6 in. (N)	Samples: Recovery, %	Samples: Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	44											
			9	50/4" (50/4")	76						9.1	
175	46											Driller reports gravel layer from 46' to 48.5'. Large gravels
	48											
	50		10	43-50/1" (50/1")	42			Slightly moist, sandy gravelly SILT @ 50'.		SA AL	12.6	
170								Bottom of boring 50.6'				
	52											
	54											
165	56											
	58											
	60											
160												
	62											
	64											
155	66											

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FIG. A-13

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, Actual elevation = 197.1 003-1316

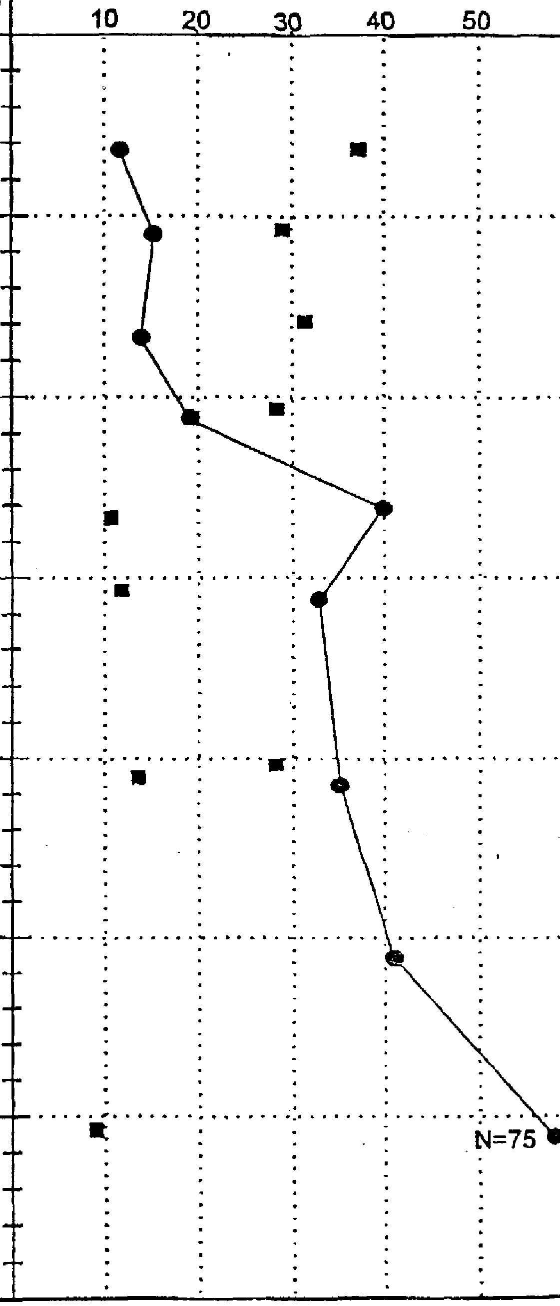
SOIL DESCRIPTION

LOG OF BORING B-1-1999

Surface Elevation: 99 Feet (Assumed)

SOIL DESCRIPTION	U.S.C.	GROUND WATER	DEPTH, ft.
Crushed rock			
Gray silt with thin light gray silt to very fine sand partings (stiff to very stiff,moist) -One seam at irregular 45 degree angle. -Thin silt to very fine sand parting between 45 degrees and vertical. -Thin partings -Sand seam at 11.5'. Few thin light gray silt to very fine sand seams	ML		5 10
Gray silty fine sand with gravel and smooth and angular dropstones (dense, moist to wet) (Drift)	SM	3/10/99 (Perched Groundwater)	15
Gray silt with very fine sand lenses (hard, moist to wet)	ML		20
Gray silty fine sand with gravel (dense, moist to wet)	SM		
Gray fine sand (dense, wet) -Water rising in boring rapidly at 23.0 feet -Silty fine sand lenses at 25.9 to 26.0 feet	SP	3/10/99 (Artesian Aquifer - 11.1 Feet Above Ground Surface)	25
Gray silty fine sand with gravel and small rounded dropstones (very dense, wet) (TILL) -Sand seam at 30.5 to 30.7 feet	SM		30
Bottom of boring at 31.5 feet on 3/10/99 Ground water encountered at 12.5 and 23.0 feet. Artesian pressure to 11.1 feet above ground elevation. Piezometer installed 3/10/99.			

Standard Penetration Resistance
(300 lb. weight, 30" drop)
● Blows per foot



LEGEND

- I Depth 2" O.D. split spoon sample driven.
- II 3" O.D. thin-wall sample
- * Liquid limit
- ■ Moisture content
- + Plastic limit
- Impervious seal
- ▽ Water level
- Piezometer tip
- P Sample pushed
- TV Torvane reading, tons/ft²
- PP Pocket penetrometer reading, tons/ft²

NOTE: The stratification lines represent the approximate boundaries between soil types and the transition may be gradual.

NELSON-COUVRETTE & ASSOCIATES, INC. CONSULTING GEOTECHNICAL ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS	Campbell Soup Slide	FIGURE A-4
	FILE NO. 255899	DATE April 1999

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FIG. A-14

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Actual Elevation = 194.5 003-1316

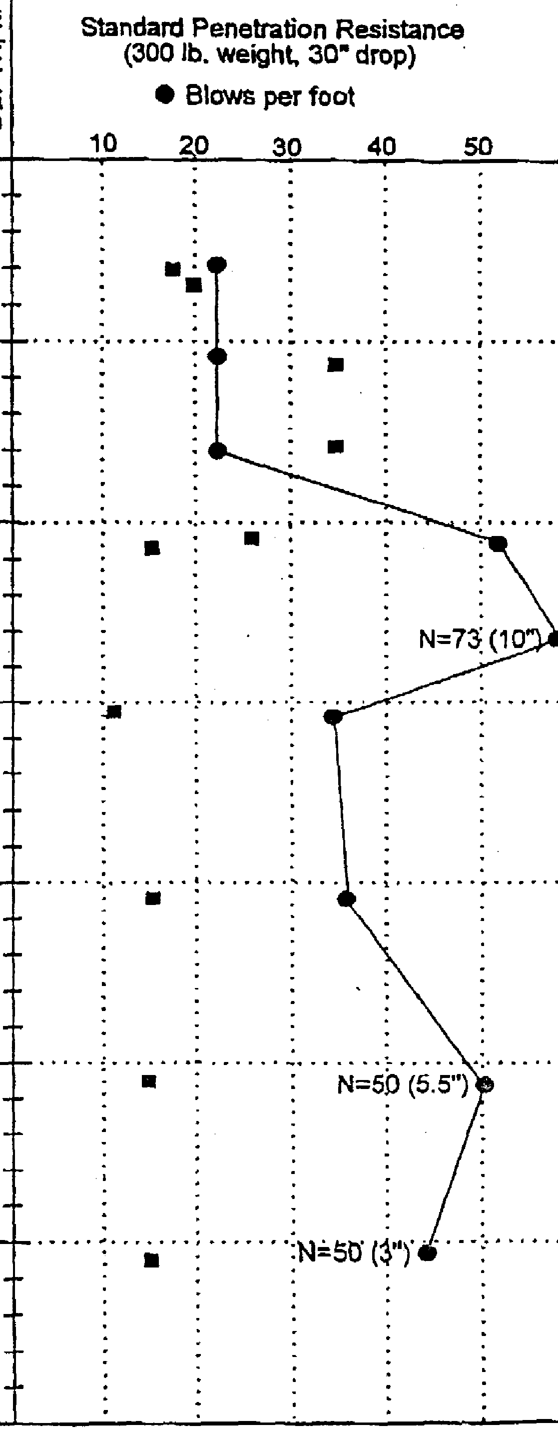
SOIL DESCRIPTION

LOG OF BORING B-2-1999

Surface Elevation: 99 Feet (Assumed)

Soil Description	U.S.C.	Samples	Ground Water	Depth, ft.
Crushed rock				
Gray silty fine sand with gravel and smooth dropstones (medium dense, moist)	SP			
Gray silt with thin light gray silt to very fine sand partings (very stiff to hard, moist to wet) -Thin parting of light gray silt to very fine sand at irregular 45 degree surfaces. Few thin light gray silt to very fine sand seams lower than 8.8 feet. -Trace seams of light gray silty to very fine sand (hard, moist to wet)	ML		3/10/99 (Perched Groundwater)	5, 10
Gray silty fine sand with gravel and smooth dropstones (medium dense to very dense, moist to wet)(Drift?)	SM			15
Gray fine sand (dense to very dense, wet) -With gravel, smooth dropstones and trace silt at 21.1 feet	SP		3/10/99 (Artesian Aquifer - 8.5 Feet Above Ground Surface)	20, 25
Gray silty fine to coarse sand with dropstones (very dense, moist to wet)(Drift?)	SM			30

Bottom of boring at 31.5 feet on 3/10/99
Ground water encountered at 12.5 and 19.0 feet
Artesian pressure to 8.5 feet above ground elevation
Piezometer installed on 3/10/99



LEGEND

- Depth 2" O.D. split spoon sample driven.
- 3" O.D. thin-wall sample
- * Liquid limit
- ■ Moisture content
- \+ Plastic limit
- Impervious seal
- Water level
- Piezometer tip
- P Sample pushed
- TV Torvane reading, tons/ft²
- PP Pocket penetrometer reading, tons/ft²

NOTE: The stratification lines represent the approximate boundaries between soil types and the transition may be gradual.

NELSON-COUVRETTE & ASSOCIATES, INC. Consulting Geotechnical Engineers, Geologists and Environmental Scientists	Campbell Soup Slide	FIGURE A-5
	FILE NO. 255899	DATE April 1999

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FIG. A-15

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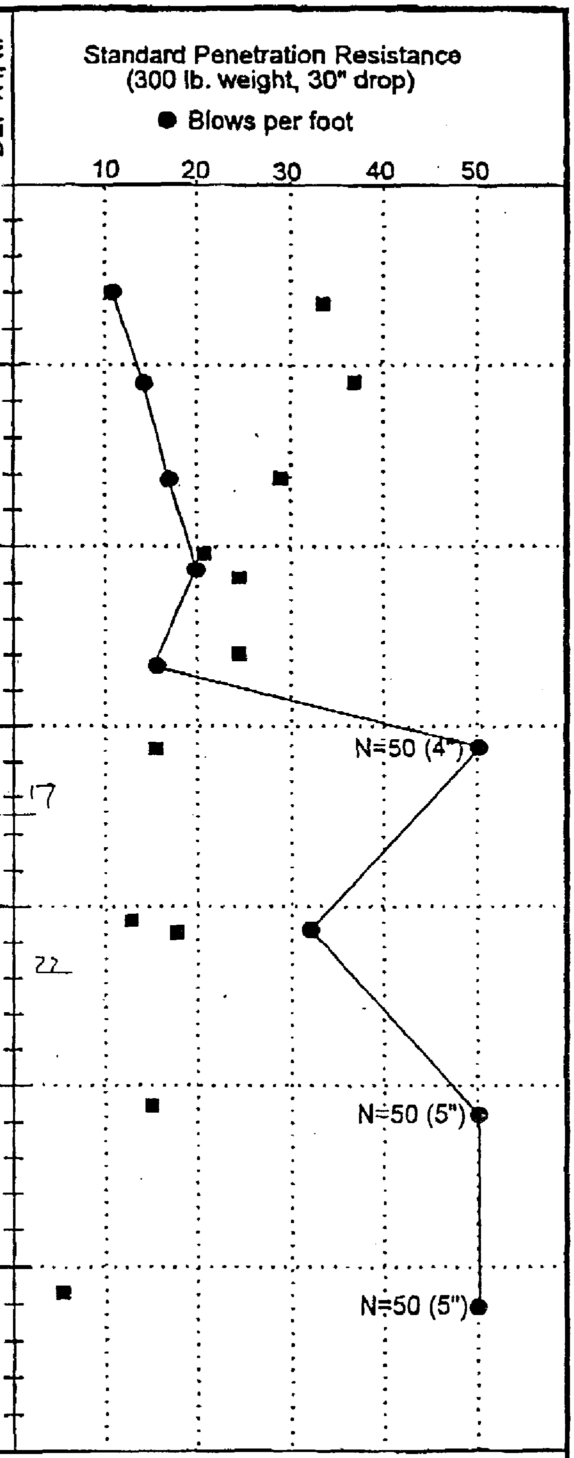
Actual Elevation = 194.4

SOIL DESCRIPTION

LOG OF BORING B-3-1999

Surface Elevation: 99 Feet (Assumed)

Soil Description	U.S.C.	Samples	Ground Water	Depth, ft.
Crushed rock				
Gray silt with thin seams of light gray silt to very fine sand partings (stiff to very stiff, moist to wet)	ML			
-With trace light gray fine sand thin partings.				5
-With fine sand partings. Sandy silt seam at 10.8 to 11.2 feet. Becomes wet				10
-With trace fine sand			3/11/99 (Perched Groundwater)	
-Becomes fine sandy silt				15
Gray silty sand with gravel and smooth dropstones (dense to very dense, moist to wet)(**Drift?**)	SM			17
				20
Gray fine sand with dropstones, grades to gray fine sand with silt (very dense, moist to wet)	SP		3/11/99 (Artesian Aquifer - 8.4 Feet Above Ground Surface)	22
-Gravel from 26.5 to 30.0 feet				25
				30
Bottom of boring at 31.4 feet on 3/11/99 Ground water encountered at 13.0 and 21.5 feet Artesian pressure to 8.4 feet above ground elevation Piezometer installed on 3/11/99				



LEGEND

- Depth 2" O.D. split spoon sample driven.
- 3" O.D. thin-wall sample
- * Liquid limit
- ■ Moisture content
- \+ Plastic limit
- Impervious seal
- Water level
- Piezometer tip
- P Sample pushed
- TV Torvane reading, tons/ft²
- PP Pocket penetrometer reading, tons/ft²

NOTE: The stratification lines represent the approximate boundaries between soil types and the transition may be gradual.

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Campbell Soup Slide	FIGURE A-6
FILE NO. 255899	DATE April 1999

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FIG. A-16

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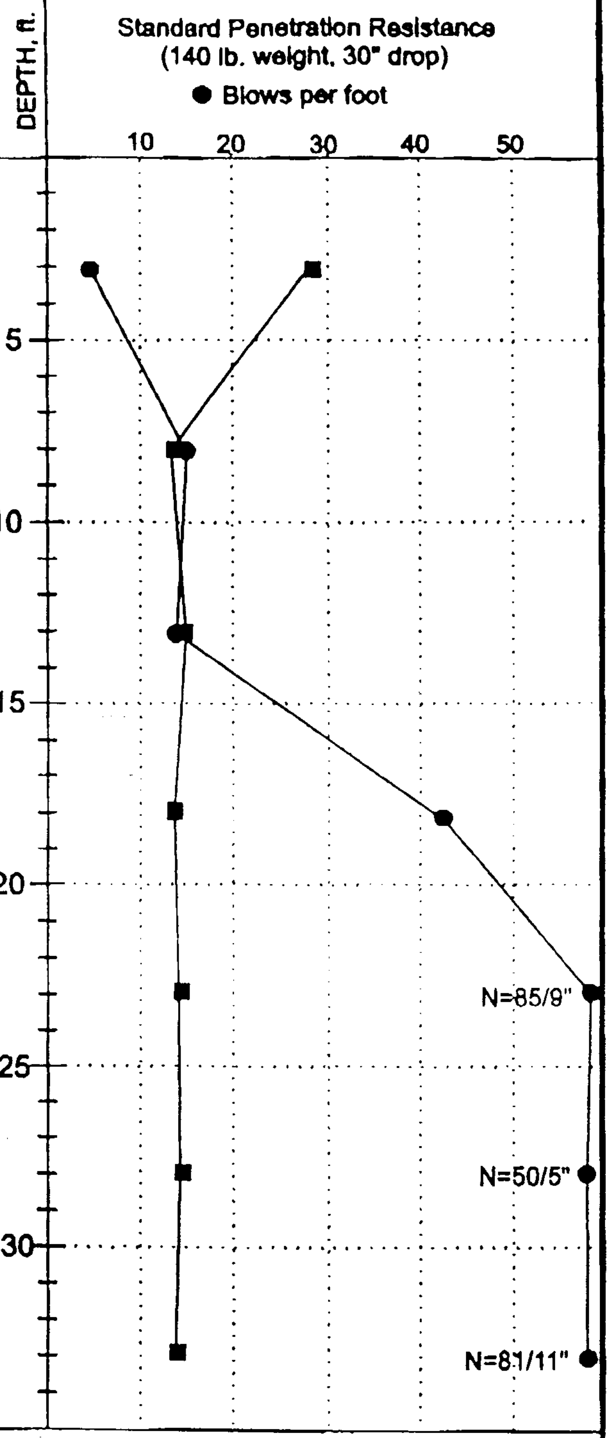
SOIL DESCRIPTION

LOG OF BORING B-1B-1999

Surface Elevation: 214.39 feet

SOIL DESCRIPTION	U.S.C.
Brown silty fine sand with gravel, concrete pieces and other debris (very loose, wet) **(Fill)** -trace rootlets Gray silty fine sand (very loose, moist)	SM
Gray fine to coarse sand with trace silt (medium dense, wet)	SW
Light brown-gray silty fine sand (medium dense moist to wet) **(Weathered Drift)**	SM
Gray silty fine sand with fine to medium sand lenses and trace gravel (dense to very dense, moist to wet) **(Drift)** -drilling harder, becomes very dense	SM

SAMPLES | GROUND WATER | DEPTH, ft.



LEGEND

- Ⅰ Depth 2" O.D. split spoon sample driven.
- Ⅱ 3" O.D. thin-wall sample
- * Liquid limit
- ■ Moisture content
- \+ Plastic limit
- Impervious seal
- ∇ Water level
- Piezometer tip
- P Sample pushed
- TV Torvane reading, tons/ft²
- PP Pocket penetrometer reading, tons/ft²

NOTE: The stratification lines represent the approximate boundaries between soil types and the transition may be gradual.

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Woodinville Business Park Building B	FIGURE A-4
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FIG. A-17
Sheet 1 of 2

SOIL DESCRIPTION LOG OF BORING B-1B-1999 (Con't) Surface Elevation: 214.39 feet	U.S.C.	SAMPLES	GROUND WATER	DEPTH, ft.	Standard Penetration Resistance (140 lb. weight, 30" drop) ● Blows per foot 10 20 30 40 50
continued from previous page	SM				
Boring terminated at 37.8 feet on 6/25/99 Perched ground water encountered at 17.5 feet on 6/25/99				40	

LEGEND

- I Depth 2" O.D. split spoon sample driven.
- II 3" O.D. thin-wall sample
- * Liquid limit
- ■ Moisture content
- \+ Plastic limit
- Impervious seal
- Water level
- Piezometer tip
- P Sample pushed
- TV Torvane reading, tons/ft^2
- PP Pocket penetrometer reading, tons/ft^2

NOTE: The stratification lines represent the approximate boundaries between soil types and the transition may be gradual.

NELSON-COUVRETTE & ASSOCIATES, INC. CONSULTING GEOTECHNICAL ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS	Woodinville Business Park Building B	FIGURE A-5
	FILE NO. 263199	DATE August 1999

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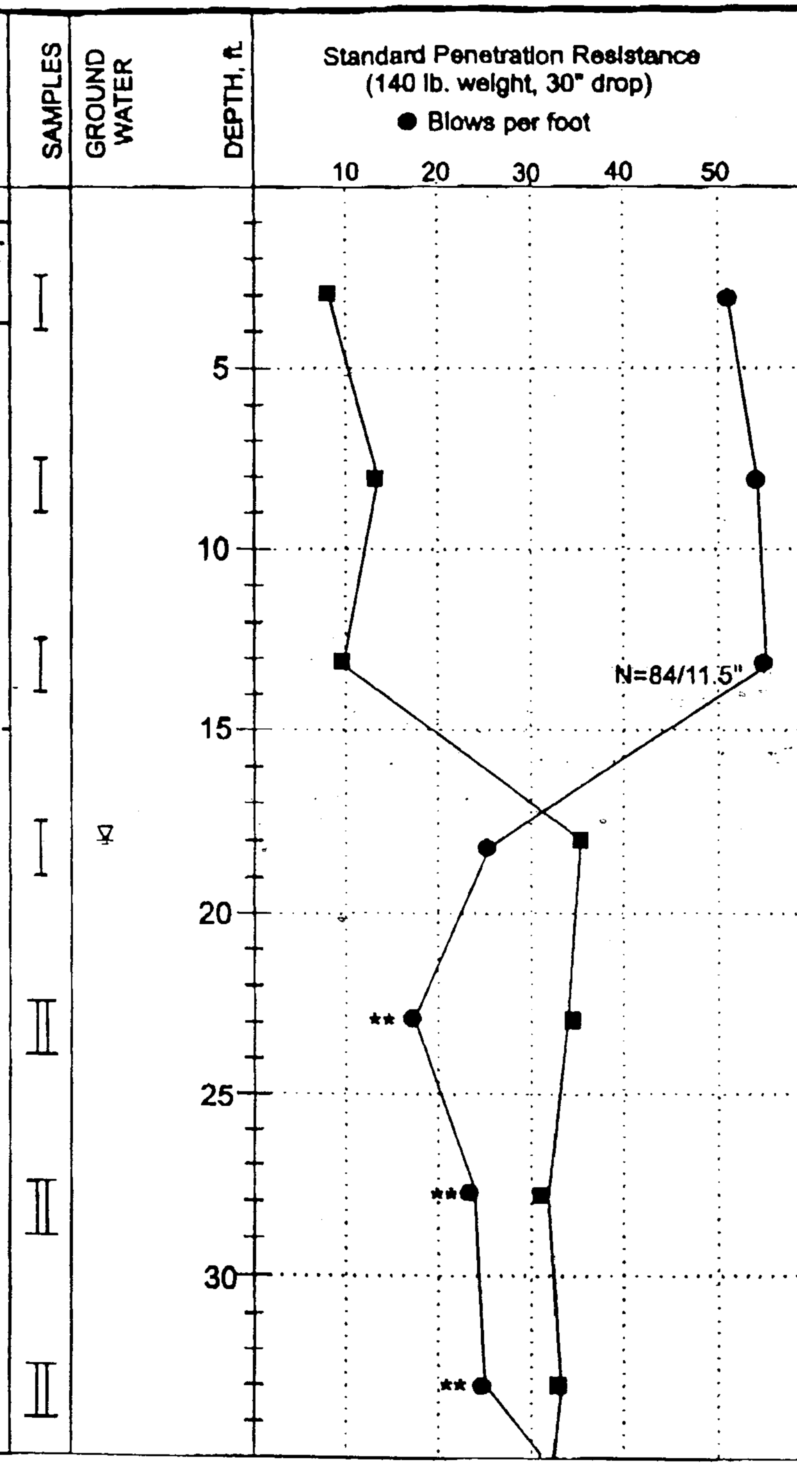
FIG. A-17

SOIL DESCRIPTION

LOG OF BORING B-2B-1999

Surface Elevation: 209.29 feet

Soil Description	U.S.C.
Light brown silty fine sand with gravel, trace cobbles and roots (loose, moist) (**Fill**)	SM
Light brown silty fine to coarse sand with trace gravel (very dense, moist)	SM-SW
Gray silty fine sand with fine to medium sand lenses and varying amounts of gravel (very dense, moist)	SM
Gray silt with light gray fine sand partings and pockets and stress fractures/planes at various angles that lessen with depth (very stiff, moist) (**Lacustrine Silt**) -At 18.0 feet a 4-inch thick fine to medium sand seam with slight water -with trace fine sand partings and pockets	ML



LEGEND

- Ⅰ Depth 2" O.D. split spoon sample driven.
- Ⅱ 3" O.D. thin-wall sample
- ** Adjusted for 300 lb. hammer
- * Liquid limit
- ■ Moisture content
- \+ Plastic limit
- Impervious seal
- ∇ Water level
- Piezometer tip
- P Sample pushed
- TV Torvane reading, tons/ft²
- PP Pocket penetrometer reading, tons/ft²

NOTE: The stratification lines represent the approximate boundaries between soil types and the transition may be gradual.

NELSON-COUVRETTE & ASSOCIATES, INC. CONSULTING GEOTECHNICAL ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS	Woodinville Business Park Building B	FIGURE A-6
	FILE NO. 263199	DATE August 1999

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SOIL DESCRIPTION **LOG OF BORING B-2B-1999** (Con't) Surface Elevation: 214.39 feet	U.S.C.	SAMPLES	GROUND WATER	DEPTH, ft.	Standard Penetration Resistance (140 lb. weight, 30" drop) ● Blows per foot 10 20 30 40 50
continued from previous page	SM				
Boring terminated at 37.8 feet on 6/25/99 Perched ground water encountered at 17.5 feet on 6/25/99				40	

LEGEND

- I Depth 2" O.D. split spoon sample driven.
- II 3" O.D. thin-wall sample
- ★ Liquid limit
- ■ Moisture content
- \+ Plastic limit
- Impervious seal
- ∇ Water level
- Piezometer tip
- P Sample pushed
- TV Torvane reading, tons/ft²
- PP Pocket penetrometer reading, tons/ft²

NOTE: The stratification lines represent the approximate boundaries between soil types and the transition may be gradual.

NELSON-COUVRETTE & ASSOCIATES, INC. CONSULTING GEOTECHNICAL ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS	Woodinville Business Park Building B	FIGURE A-5
	FILE NO. 263199	DATE August 1999

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FIG. A-18
Sheet 2 of 2

ATTACHMENT B

PROPOSED TREATMENT PLANT GEOTECHNICAL LABORATORY TESTING PROCEDURES AND RESULTS

Attachment B
Proposed Treatment Plant Geotechnical Laboratory Testing Procedures and Results

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Figure B-2 Grain Size Distribution, Boring PB-4
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Figure B-4 Grain Size Distribution, Boring PB-7B
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Figure B-6 Plasticity Chart, Boring PB-2

INTRODUCTION

This attachment contains descriptions of the procedures and the results of the geotechnical laboratory tests performed on soil samples retrieved from the mud-rotary borings at the proposed SR-9 treatment plant site. The laboratory testing program included a variety of tests to classify the soils into similar geologic groups, to characterize each geologic unit, and to provide data for the interpretive report. The laboratory testing was performed by an engineer or an experienced technician at the Shannon & Wilson, Inc. laboratory in Seattle.

Classification and index laboratory tests included visual classification and tests to determine natural water content, grain-size distribution, and Atterberg limits. The following sections describe the laboratory testing procedures.

VISUAL CLASSIFICATION

All of the soil samples recovered from the borings were visually classified in our laboratory using a system based on American Society for Testing of Materials (ASTM) Designation: D-2487, Standard Test Method for Classification of Soil for Engineering Purposes, and ASTM Designation: D-2488, Standard Recommended Practice for Description of Soils (Visual-Manual Procedure). This visual classification method allows for convenient and consistent comparison of soils from widespread geographic areas. Using this method, the soils can be classified by using the Unified Soil Classification System (USCS). The individual sample classifications have been incorporated into the boring logs presented in Attachment A. The USCS codes are also shown on Figures B-1 through B-6.

WATER CONTENT DETERMINATION

The natural water content of all soil samples recovered from the borings were determined in general accordance with ASTM Designation: D-2216, Standard Method of Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures. Comparison of natural water content of a soil with its index properties can be useful in characterizing soil unit weight, consistency, compressibility, and strength. The water contents are plotted on the boring logs presented in Attachment A.

GRAIN-SIZE ANALYSIS

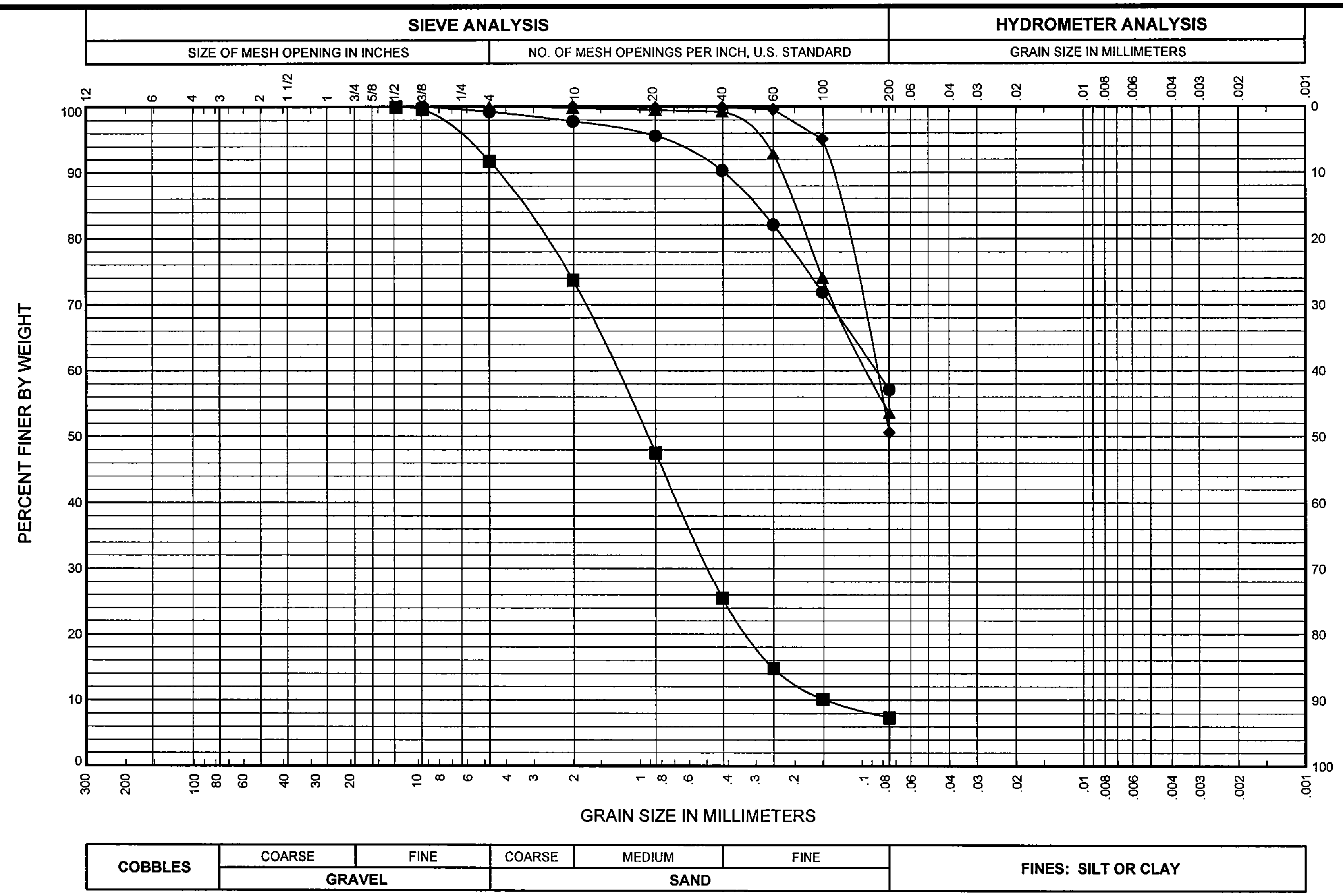
Grain-size analyses were performed on selected samples of granular soil in general accordance with ASTM Designation: D-422, Standard Method for Particle-Size Analysis of Soils. A grain-size distribution is used to assist in classifying soils and to provide correlation with soil properties, including permeability and capillarity. Results of the grain size analyses are plotted on the grain-size distribution curves presented in Figures B-1 through B-5b. Each gradation sheet provides the USCS group symbol, the sample description, and natural water content.

ATTERBERG LIMITS DETERMINATION

Soil plasticity was determined by performing Atterberg Limits tests on selected fine-grained samples. The tests were conducted in general accordance with ASTM Designation: D-4318, Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils. The Atterberg Limits include Liquid Limit (LL), Plastic Limit (PL), and Plasticity Index (PI=LL-PL). They are generally used to assist in classification of soils, indicate soil consistency (when compared with natural water content), and provide correlation to soil properties including compressibility and strength. The results are shown graphically on the boring logs in Attachment A and are plotted on the plasticity chart presented in Figure B-6. The plasticity chart provides the USCS group symbol, sample description, and natural water content.

REFERENCE

American Society for Testing and Materials (ASTM), 2003, 2003 Annual book of standards, Construction, v. 04.08, Soil and rock (I): D 420 – D 5779: West Conshohocken, Pa.



GSAMAIN1 21-09869.GPJ SHAN WIL.GDT 7/16/03

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● PB-2, S-8	20.0	ML	Gray, fine to medium sandy SILT	57.1	12.8			
■ PB-2, S-19	65.0	SW-SM	Gray, slightly silty, slightly gravelly SAND	7.4	12.8			
▲ PB-2, S-22	80.0	ML	Gray, fine sandy SILT	53.6	21.5			
◆ PB-2, S-25	95.0	ML	Gray, fine sandy SILT	50.6	24.9			

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

GRAIN SIZE DISTRIBUTION
BORING PB-2

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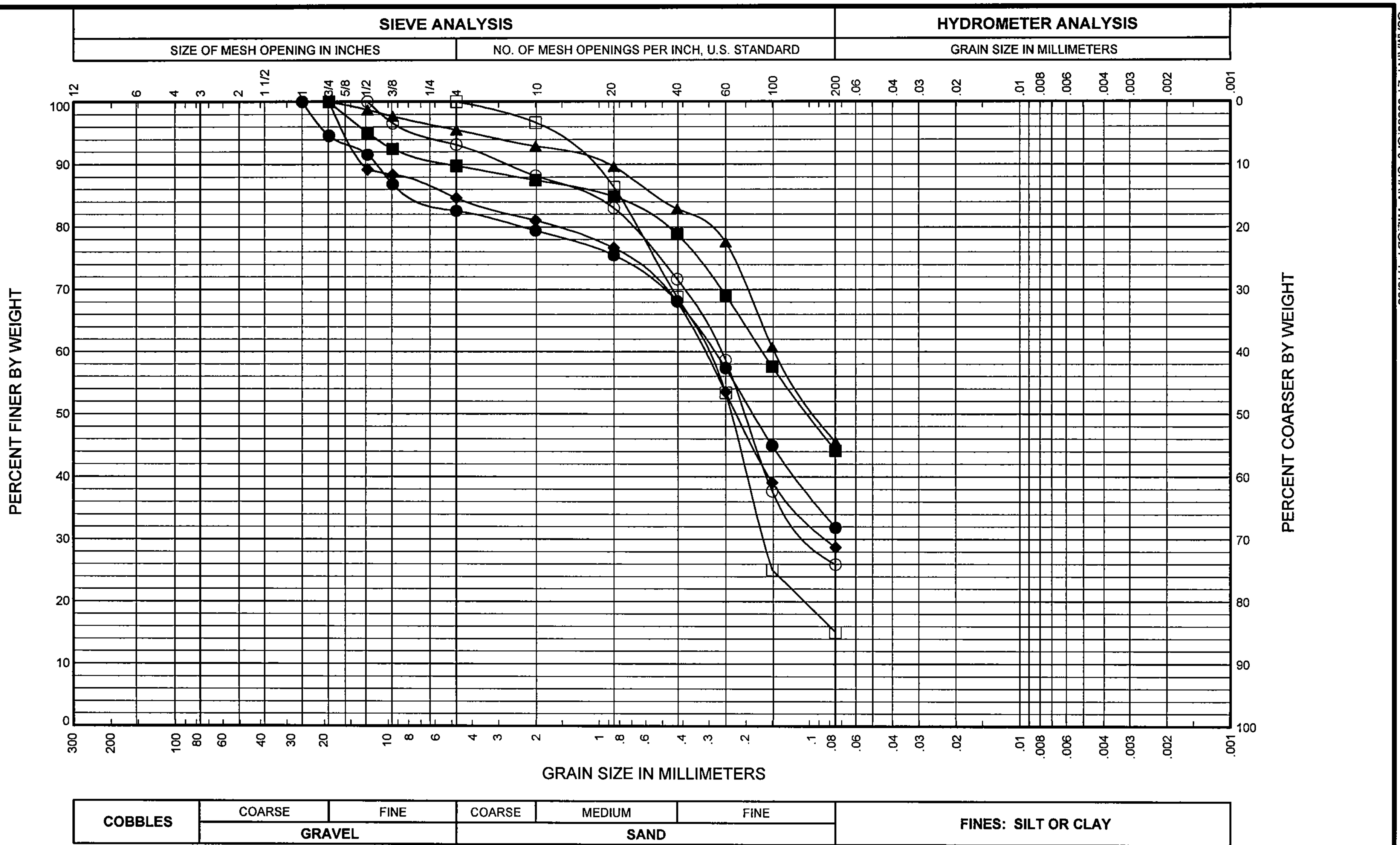
FIG. B-1

FIG. B-1



BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● PB-4, S-4	10.0	SM	Brown-gray, gravelly, silty SAND	31.8	11.9			
■ PB-4, S-9	22.5	SM	Gray, slightly clayey, slightly gravelly, silty, fine to medium SAND	44.2	9.9			
▲ PB-4, S-12	30.0	SM	Gray, slightly clayey, silty, fine to medium SAND, trace of gravel	45.5	12.4			
◆ PB-4, S-18	60.0	SM	Gray, slightly clayey, gravelly, silty SAND	28.7	10.7			
○ PB-4, S-23	85.0	SM	Gray, slightly clayey, slightly gravelly, silty SAND	25.9	10.3			
□ PB-4, S-26	100.0	SM	Gray, silty, fine to medium SAND	15.1	13.9			

Brightwater Treatment Plant
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GRAIN SIZE DISTRIBUTION
BORING PB-4

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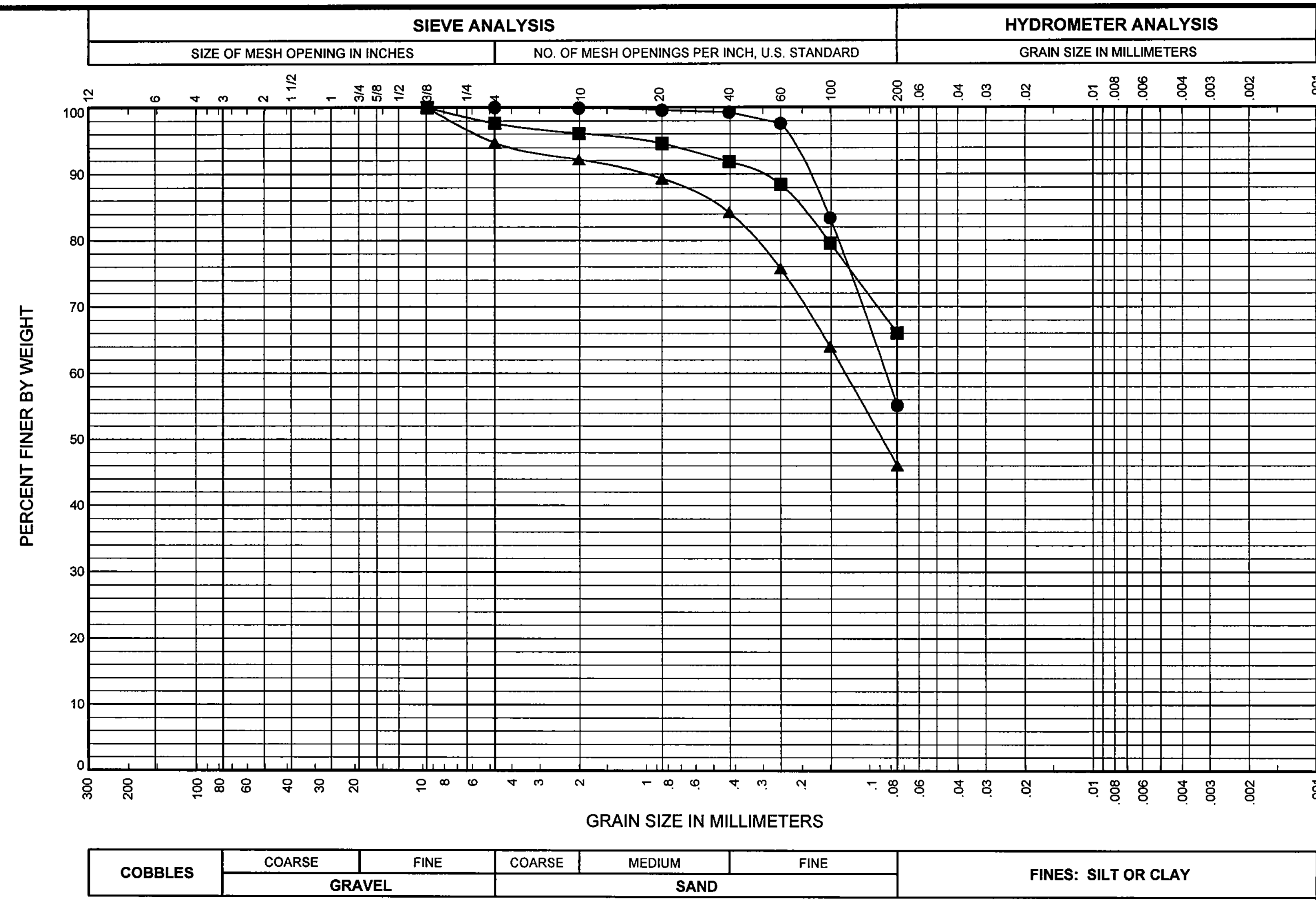
FIG. B-2

FIG. B-2



BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● PB-6, S-4	10.0	ML	Gray, fine sandy SILT	55.1	19.0			
■ PB-6, S-9	22.5	ML	Gray, fine to medium sandy SILT, trace of gravel	66.1	13.7			
▲ PB-6, S-11	27.5	SM	Gray, slightly gravelly, silty, fine to medium SAND	46.0	14.9			

Brightwater Treatment Plant
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GRAIN SIZE DISTRIBUTION
BORING PB-6

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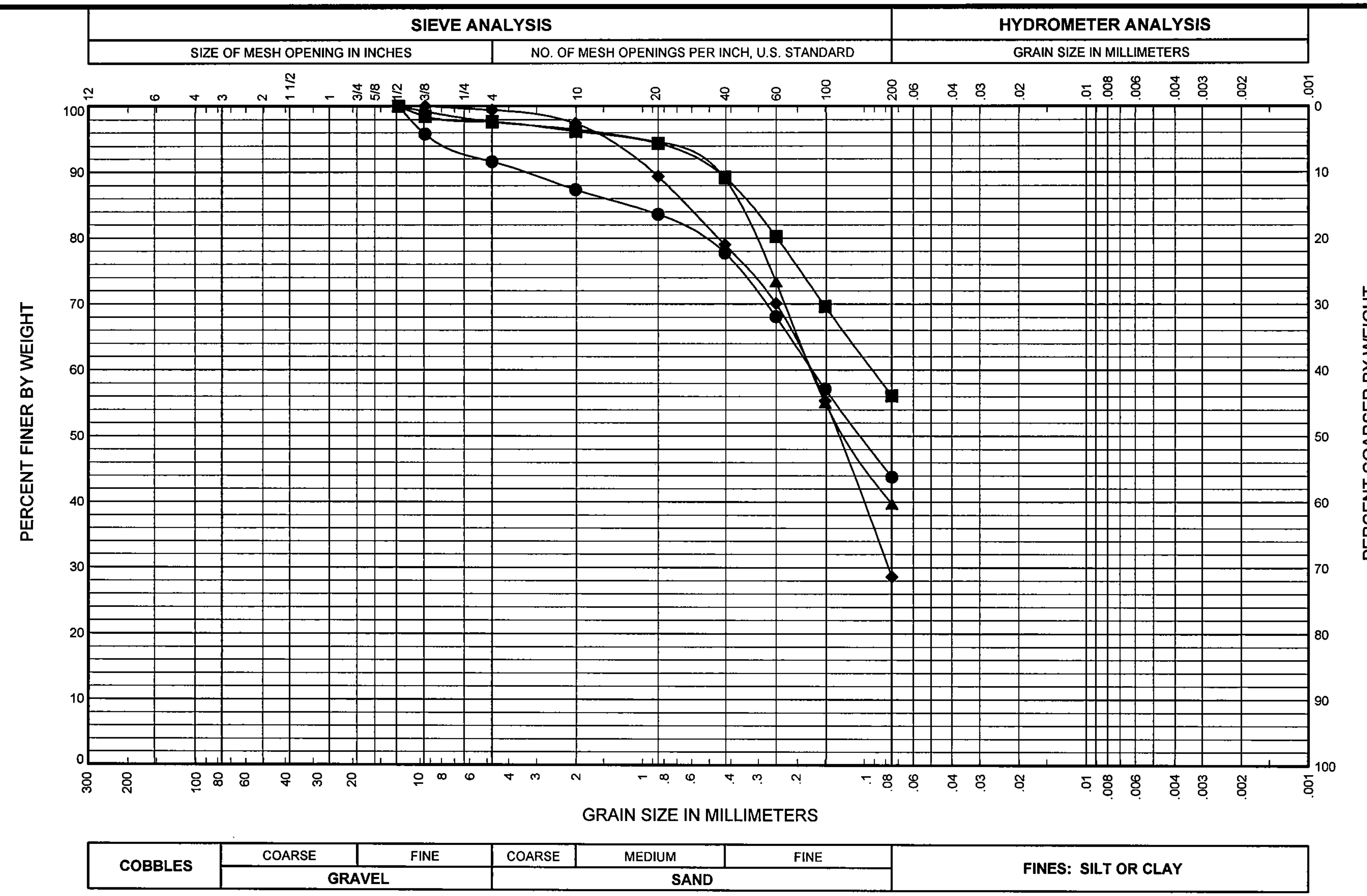
FIG. B-3

GSAMAIN1 21-09869.GPJ SHAN_WIL.GDT 7/16/03

FIG. B-3



BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● PB-7B, S-4	15.0	SM	Brown, slightly gravelly, silty, fine to medium SAND, trace of clay	43.8	13.5			
■ PB-7B, S-9	27.5	ML	Brown-gray, fine to medium sandy SILT, trace of gravel	56.1	12.6			
▲ PB-7B, S-13	45.0	SM	Gray, silty, fine to medium SAND, trace of gravel	39.7	15.8			
◆ PB-7B, S-18	70.0	SM	Gray, silty, fine to medium SAND	28.6	17.1			

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

GRAIN SIZE DISTRIBUTION BORING PB-7B

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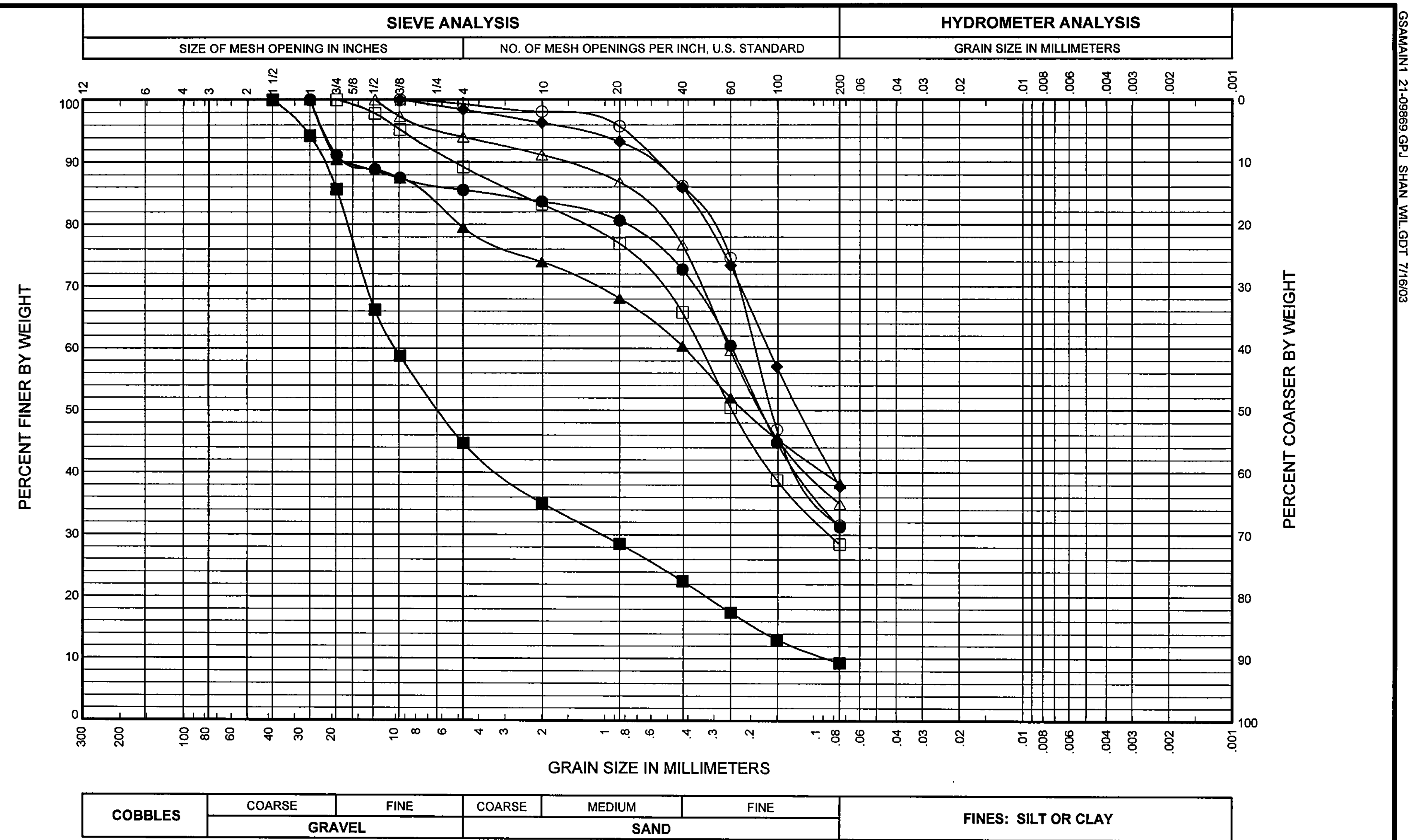
FIG. B-4

FIG. B-4



BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● PB-10, S-4	10.0	SM	Brown-gray, gravelly, silty, fine to medium SAND	31.3	14.6			
■ PB-10, S-6	15.0	GW-GM	Brown, slightly silty, sandy GRAVEL	9.3	8.0			
▲ PB-10, S-8	20.0	SM	Gray-brown, slightly clayey, gravelly, silty SAND	38.2	13.3			
◆ PB-10, S-11	27.5	SM	Brown, silty, fine to medium SAND, trace of gravel	37.7	18.1			
○ PB-10, S-12	30.0	SM	Brown, silty, fine to medium SAND	31.5	19.5			
□ PB-10, S-15	45.0	SM	Gray, slightly gravelly, silty SAND	28.5	9.8			
△ PB-10, S-20	70.0	SM	Gray, slightly gravelly, silty, fine to medium SAND	35.0	13.6			

Brightwater Treatment Plant
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GRAIN SIZE DISTRIBUTION
BORING PB-10

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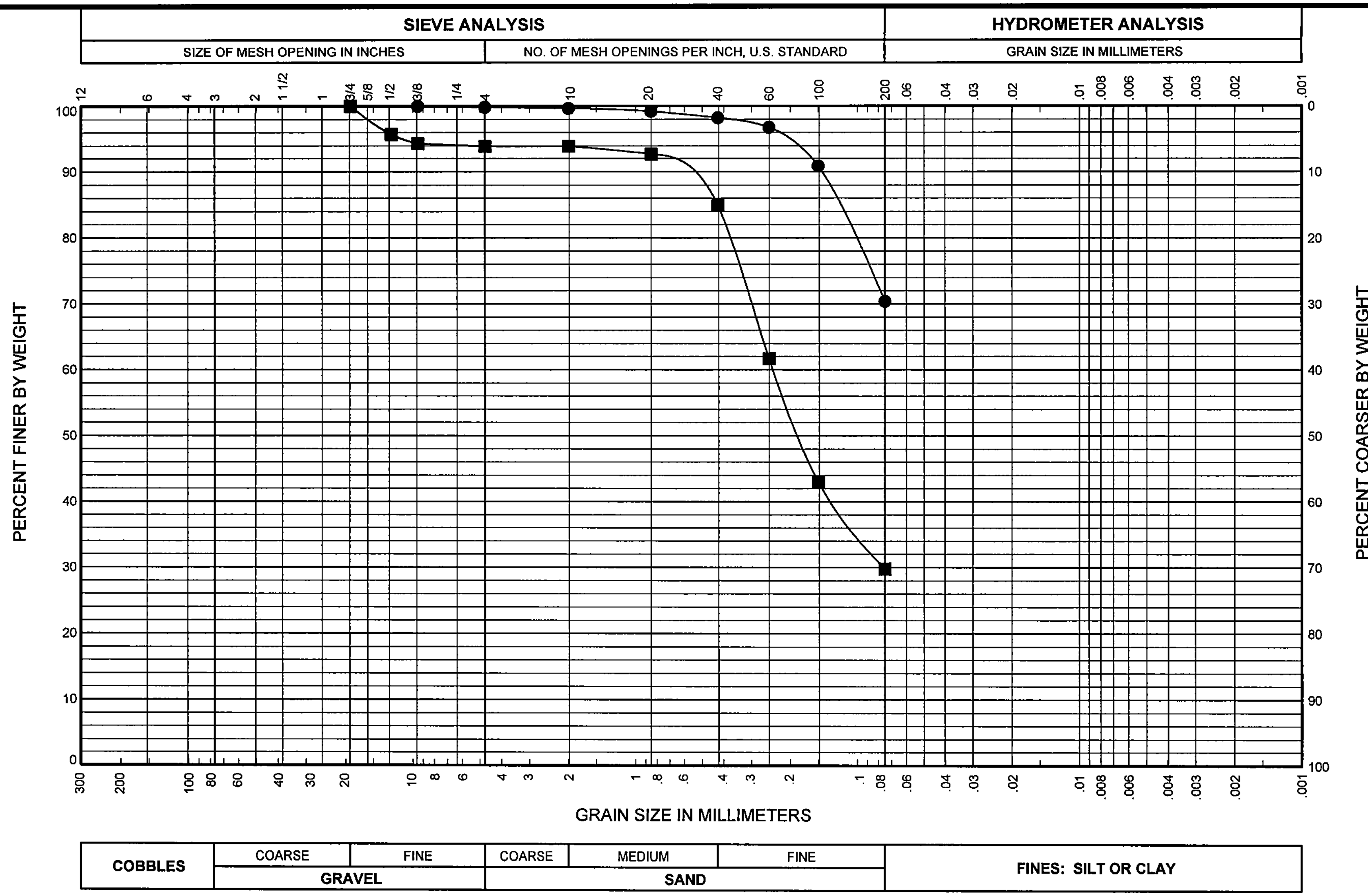
FIG. B-5a

FIG. B-5a



BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● PB-10, S-22	80.0	ML	Gray, fine sandy SILT; scattered organics	70.4	25.6			
■ PB-10, S-24	90.0	SM	Gray, slightly gravelly, silty, fine to medium SAND	29.8	21.4			

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

GRAIN SIZE DISTRIBUTION BORING PB-10

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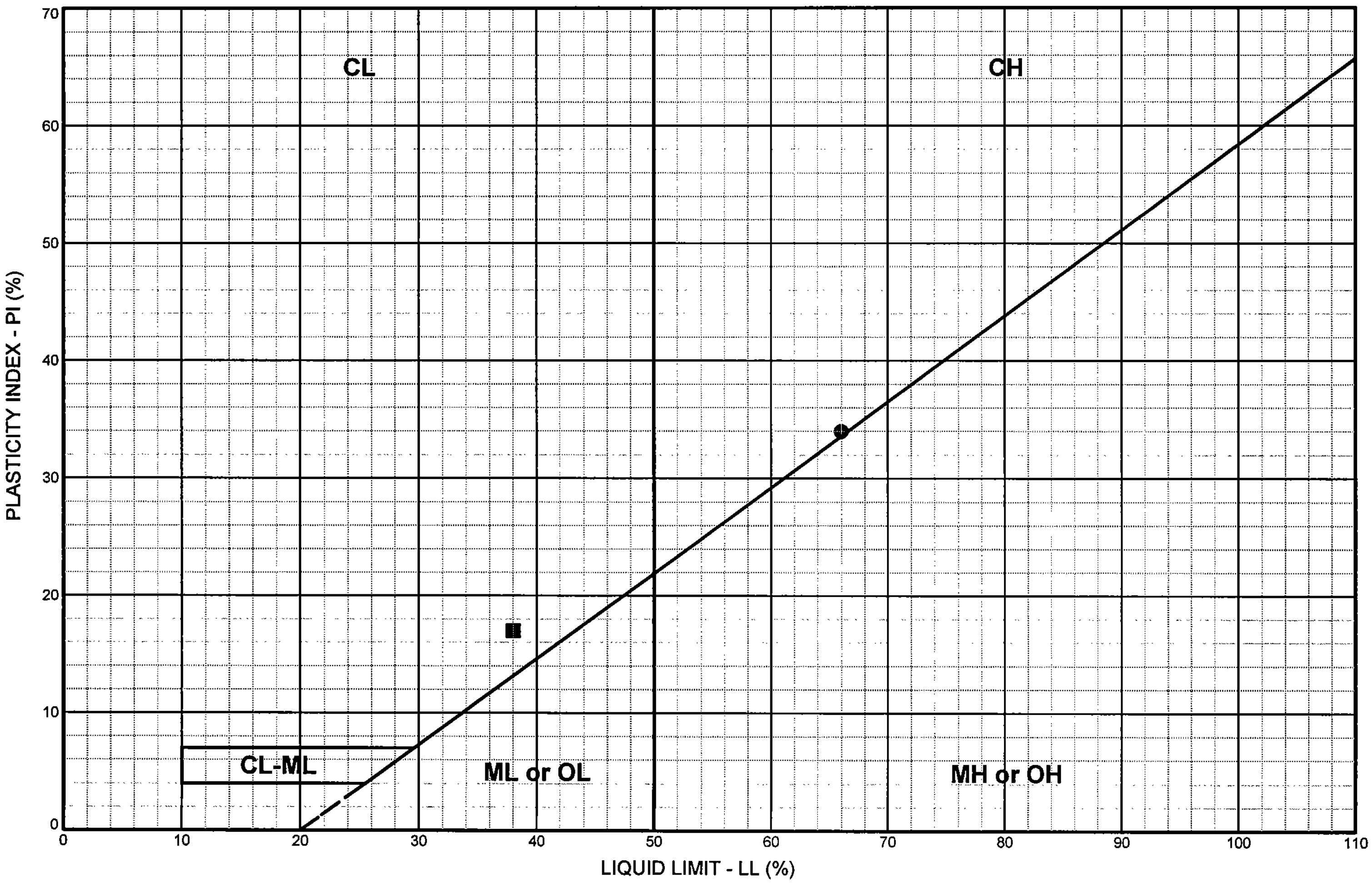
FIG. B-5b

GSAMAIN1 21-09869.GPJ SHAN WIL.GDT 7/16/03

FIG. B-5b



LEGEND

CL: Low plasticity inorganic clays; sandy and silty clays

CH: High plasticity inorganic clays

ML or OL: Inorganic and organic silts and clayey silts of low plasticity

MH or OH: Inorganic and organic silts and clayey silts of high plasticity

CL-ML: Silty clays and clayey silts

ATTMAIN1 21-09869.GPJ SHAN WIL.GDT 7/16/03

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
● PB-2, S-15	45.0	CH	Gray, silty CLAY	66	32	34	29.1	
■ PB-2, S-24	90.0	CL	Gray, silty CLAY	38	21	17	24.0	

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

PLASTICITY CHART
BORING PB-2

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FIG. B-6

FIG. B-6

ATTACHMENT C

PROPOSED IPS FIELD EXPLORATION

Attachment C
Proposed IPS Field Exploration

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VIBRATING WIRE PIEZOMETER MEASUREMENTS **4**

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FIGURES

Figure C-1 Soil Classification and Log Key (4 sheets)
Figure C-2 Geologic Unit Explanation and Descriptions
Figure C-3 Log of Boring PB-12 (11 sheets)
Figure C-4 Soil Core Photographs, Boring PB-12, 20 to 501 Feet (20 sheets)

INTRODUCTION

The subsurface exploration for the proposed IPS at the SR-9 site consisted of drilling one boring, designated PB-12, to a depth of 501 feet using sonic coring and wireline soil coring techniques. The exploration location is shown on the Site and Exploration Plan, presented as Figure 2 after the main text of this data report. Other members of the pre-design team surveyed the exploration location and elevation.

A Shannon & Wilson representative was not on site for vacuuming out and setting the 3-foot-diameter casing in the upper 20 feet. Camp Dresser McKie (CDM) observed the cuttings and provided Shannon & Wilson with a verbal description. A Shannon & Wilson representative was on site during sonic and wireline coring; our field representative made a preliminary field log of the core samples, photographed the core runs, and handled the transportation of the core. Shannon and Wilson also operated air-monitoring equipment for health and safety monitoring and contaminant screening during the first day of sonic coring. No contaminants were noted during this screening. CDM and their drill crew were contracted directly to King County. CDM also had a representative on site to direct the drill crew and help handle the samples. Work followed CDM’s temporary erosion/spill control and health and safety plans.

SOIL CLASSIFICATION

An engineer from Shannon & Wilson, Inc. was present throughout the sonic coring and wireline soil coring operations for the boring. Classification of the boring samples was based on American Society for Testing and Materials (ASTM) Designation: D 2487-98, Standard Test Method for Classification of Soil for Engineering Purposes, and ASTM Designation: D 2488-93, Standard Recommended Practice for Description of Soils (Visual-Manual Procedure). The Unified Soil Classification System (USCS), as described on Figure C-1 of this attachment, was used to classify the soils encountered in the soil boring. For quality assurance purposes, an engineering geologist also went through the samples and performed a detailed classification of the soil in our warehouse. The boring log in this attachment represents our interpretation of the contents of the field logs and incorporates the results of our geotechnical laboratory testing, which are described in Attachment D.

SONIC CORE DRILLING

Sonic drilling method was used for drilling and continuously sampling boring PB-12 from 20 to 215 feet bgs. CDM subcontracted Boart Longyear to do the sonic coring; the coring took place between March 27 and 29, 2003. The sonic drilling technique vibrates the entire drill column at a frequency range between 50 and 150 hertz or cycles per second. This frequency falls within the lower range of sound vibration that can be detected by the human ear, thus the term "sonic" has been commonly used to describe this drilling system. The sonic drill rig has a specially designed hydraulically powered drill head that generates adjustable high frequency vibrational forces. The sonic head is attached directly to the core barrel, drill rod or outer casing, inputting the high frequency vibrations through the drill steel to the face of the drill bit. In addition to the vibratory input to the drill column, down-pressure and rotation can be slowly applied to assist in penetration.

Soil samples were obtained using a 6-inch inside-diameter (I.D.) and 20-foot-long solid core barrel. After advancing the core barrel a specified distance (run), the drill column and core barrel were then removed from the borehole. The core sample was taken directly from the core barrel by vibrating it into an 8-inch-diameter plastic baggie-like sleeve. The vibratory action of the sonic coring can result in an expanded (or longer) core recovery than the actual length of the core run. This sample expansion was taken into account on our log and on the core box markings. The length of the runs typically varied between 5 and 10 feet but sometimes were as short as 2 feet or as long as 18 feet. The short runs (less than 4 feet) were usually conducted following the final clean-out pass. Optimum penetration rates were obtained when the vibration frequency and down-pressure allowed the smoothest penetration and/or core recovery. The driller monitored the vibration frequency and down-pressure by watching the oil pressure gauges in the system.

After a core sample was taken, the outer casing was advanced to the last sampling depth. The outer casing was 8 5/8-inch outside diameter (O.D.) between 0 and 148 feet, and 7 5/8-inch O.D. from 148 to 215 feet. The outer casing was advanced down completely dry or with water depending upon the formation being drilled. Following the casing advancement, the drill cuttings inside the casing were removed with the core barrel and dumped into drums. When heaving occurred in the clean sand and gravel layers between approximately 120 and 150 feet, the driller kept a water head inside the outer casing about 6 to 8 feet above the ground surface by continually pouring water into the casing. This method apparently controlled the heaving problems.

The recovered soil samples held by plastic sleeves were placed onto split PVC pipes. The plastic sleeves were cut open to allow preliminary field classification and photographing performed by the Shannon & Wilson field representative. After preliminary logging and photographing, the samples were inserted into new plastic sleeves and placed in core boxes for transportation. The core boxes were labeled with boring designation, depth and core run numbers and returned to the Shannon & Wilson warehouse for additional classification and testing.

WIRELINE SOIL CORE DRILLING

A rotary coring method using a wireline, double-tube core barrel was used to continuously sample boring PB-12 between the depths of 215 and 501 feet. CDM subcontracted Cascade Drilling to do the wireline coring; the coring took place between April 1 and 5, 2003. The double-tube core barrel consists of a 5-inch O.D. outer barrel with an attached 6-inch-diameter coring bit, and a swivel-type inner core barrel sampling tube with about a 3.3-inch I.D. The flush-sided outer barrel or casing rotates as it is advanced while the inner sampling tube remains stationary. The inner sampling tube is lowered to the bottom of the casing by a wireline and latched into the lead core barrel. Drilling mud is pumped out of a mud tank at the ground surface, down the casing and around the inner sampling tube, out through the bit and up the annulus of the borehole between the outer barrel and borehole, and back into the mud tank. The drilling fluid used was a Quick Gel manufactured by Baroid. Any significant drilling action was noted on the boring log.

This coring method generally helps protect the core from the drilling fluid and reduces the torsional forces transmitted to the core. However, some of the soils encountered during drilling were eroded easily. In order to increase the quality of soil recovered, the circulation of the drilling fluid and the run length were varied. By reducing the circulation of the drilling fluid, soil tended to accumulate between the outer core barrel bit and the shoe of the inner sampling tube, applying pressure to the latching system. When this pressure was significant enough to prevent the release of the inner barrel, the outer casing was retrieved and the sampling tube was manually released.

Samples retrieved in the sampling tube were ejected by water onto a split PVC pipe. The collected samples were preliminarily classified and recorded on field logs by an engineer along with the percent of sample recovered. Recovery is the percentage of the length of the soil recovered to the length of soil cored, or run length. Photographs were taken of all recovered soil samples and were identified by the cored depth and run (or sample) number. The soil samples and PVC pipes were encased in plastic sleeves and stored in wooden core boxes. The core boxes were labeled with boring designation, depth and core run numbers, and returned to the Shannon & Wilson warehouse for additional classification and testing.

DETAILED CORE LOGGING

In the Shannon & Wilson sample warehouse, the plastic sleeves were removed from the core samples so that additional observation could be made. Because of a disturbed rind along the outside of the sonic core induced by the vibratory sampling process, and to better observe the structure of the soil from both sonic and wireline coring, the samples were split lengthwise to identify intact composition, texture, and sedimentary features. One half of the split core was retained in the split PVC pipe to protect the sample; this half of the core was photographed in the warehouse. Following photographing and using the remaining half of the split core, portions of clay and silt samples were further broken apart to reveal discontinuities such as slickensides, zones of shearing, and fractures. Portions of the soil samples were removed and retained for geotechnical laboratory testing.

Where possible, relatively “undisturbed” blocks of each different type of cohesive material were taken from the core and stored in a manner to preserve the structure and moisture for unit weight and permeability testing in the laboratory. This was done prior to splitting the core.

The half of the sample that was photographed and retained in the split PVC pipe was placed in clear shrink wrap (plastic sleeve) material. Two layers of shrink-wrap were used with wet paper towels between the layers to help prevent desiccation of the soil. The shrink-wrap was sealed with heat and trimmed, and the shrink-wrapped samples returned to the core boxes for storage.

VIBRATING WIRE PIEZOMETER INSTALLATION

Five vibrating wire piezometers (VWPs) were installed in the completed boring at depths jointly determined by Shannon & Wilson, CDM, CH2M HILL, and with assistance from Mueser Rutledge Consulting Engineers. The VWP depths are approximately 30, 122, 276, 352, and 442 feet below ground surface and are shown on the boring log in Figure C-3. The VWPs were calibrated, hung at the target installation depths, and surrounded with bentonite grout. CDM provided the VWPs and an 18-inch-square traffic-bearing surface box. Shannon and Wilson provided the VWP readout box to obtain calibration readings. No standpipe monitoring wells were installed due to the large artesian groundwater heads encountered.

VIBRATING WIRE PIEZOMETER MEASUREMENTS

Three sets of measurements were performed in April and May 2003 at each of the five VWPs installed within PB-12. Measurements were made using a VWP readout box. Data were later converted to feet of water and subsequently to elevation in feet relative to the NAVD 88 datum. The elevations are provided in Table 1 of the main text of this report.

BORING LOG AND CORE PHOTOGRAPHS

The log for boring PB-12 at the proposed IPS site is presented in this attachment as Figure C-3. A boring log is a written record of the subsurface conditions encountered. It graphically illustrates the interpreted geologic units (layers) encountered in the boring and the USCS symbol of each geologic layer. It also includes the natural water content, Atterberg Limits, discontinuities, and both general and detailed soil descriptions. Other information shown on the boring log includes VWP measurements, ground surface elevation (NAVD 88), and the borehole location. Figure C-2 presents the geologic unit explanation and descriptions. Details of drilling observations are shown on the boring log. Figure C-4 presents the warehouse photographs of the sonic and wireline core.

REFERENCE

American Society for Testing and Materials (ASTM), 2003, 2003 Annual book of standards, Construction, v. 04.08, Soil and rock (I): D 420 – D 5779: West Conshohocken, Pa.

Shannon & Wilson, Inc. (S&W), uses a soil classification system modified from the Unified Soil Classification System (USCS). Elements of the USCS and other definitions are provided on this and the following page. Soil descriptions are based on visual-manual procedures (ASTM D 2488-93) unless otherwise noted.

SHANNON & WILSON, INC., CLASSIFICATION OF SOIL CONSTITUENTS

- MAJOR constituents compose more than 50 percent, by weight, of the soil. Major constituents are capitalized (SAND).
- Minor constituents compose 12 to 50 percent of the soil and precede the major constituents (silty SAND). Minor constituents preceded by "slightly" compose 5 to 12 percent of the soil (slightly silty SAND).
- Trace constituents compose 0 to 5 percent of the soil (slightly silty SAND, trace of gravel).

MOISTURE CONTENT DEFINITIONS

Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, from below water table

ABBREVIATIONS

CL	Core Loss
Elev.	Elevation
ft	feet
HSA	Hollow Stem Auger
ID	Inside Diameter
in	inches
lbs	pounds
Mon.	Monument cover
N	Blows for last two 6-inch increments
NA	Not Applicable or Not Available
OD	Outside Diameter
OVA	Organic Vapor Analyzer
PID	Photoionization Detector
ppm	parts per million
PVC	Polyvinyl Chloride
SS	Split Spoon sampler
SPT	Standard Penetration Test
USCS	Unified Soil Classification System
VWP	Vibrating Wire Piezometer
WLI	Water Level Indicator

GRAIN SIZE DEFINITIONS

DESCRIPTION	SIEVE SIZE
FINES	< #200 (0.075 mm)
SAND*	
· Fine	#200 - #40 (0.425 mm)
· Medium	#40 - #10 (2 mm)
· Coarse	#10 - #4 (4.75 mm)
GRAVEL*	
· Fine	#4 - 3/4 inch
· Coarse	3/4 - 3 inches
COBBLES	3 - 12 inches
BOULDERS	> 12 inches

* Unless otherwise noted, sand and gravel, when present, range from fine to coarse in grain size.

RELATIVE DENSITY / CONSISTENCY

COARSE-GRAINED SOILS		FINE-GRAINED/COHESIVE SOILS	
N, SPT, BLOWS/FT.	RELATIVE DENSITY	N, SPT, BLOWS/FT.	RELATIVE CONSISTENCY
0 - 4	Very loose	<2	Very soft
4 - 10	Loose	2 - 4	Soft
10 - 30	Medium dense	4 - 8	Medium stiff
30 - 50	Dense	8 - 15	Stiff
Over 50	Very dense	15 - 30	Very stiff
		Over 30	Hard

WELL AND OTHER SYMBOLS

Concrete	Asphalt or PVC Cap
Bentonite Grout	Vibrating Wire Piezometer (VWP)
Bentonite Seal	1 ← Well Number; Monitoring Well Groundwater Level
Silica Sand	1 ← VWP Number; VWP Groundwater Level
1-1/2" to 2" I.D. PVC Screen (0.010 to 0.020 Slot)	
Slough	

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SOIL CLASSIFICATION AND LOG KEY

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FIG. C-1
Sheet 1 of 4

UNIFIED SOIL CLASSIFICATION SYSTEM
(From ASTM D 2488-93 & 2487-93)

MAJOR DIVISIONS			GROUP/GRAPHIC SYMBOL ②	TYPICAL DESCRIPTION
Coarse-Grained Soils *(more than 50% retained on No. 200 sieve)* [use Dual Symbols for 5 - 12% Fines (i.e. GP-GM)] ①	Gravels *(more than 50% of coarse fraction retained on No. 4 sieve)*	Clean Gravels ① *(less than 5% fines)*	GW	Well-Graded Gravels, Gravel-Sand Mixtures, Little or No Fines
			GP	Poorly Graded Gravels, Gravel-Sand Mixtures, Little or No Fines
		Gravels with ① Fines *(more than 12% fines)*	GM	Silty Gravels, Gravel-Sand-Silt Mixtures
			GC	Clayey Gravels, Gravel-Sand-Clay Mixtures
	Sands *(50% or more of coarse fraction passes the No. 4 sieve)*	Clean sands ① *(less than 5% fines)*	SW	Well-Graded Sands, Gravelly Sands, Little or No Fines
			SP	Poorly Graded Sand, Gravelly Sands, Little or No Fines
		Sands with ① Fines *(more than 12% fines)*	SM	Silty Sands, Sand-Silt Mixtures
			SC	Clayey Sands, Sand-Silt Mixtures
Fine-Grained Soils *(50% or more passes the No. 200 sieve)*	Silts and Clays *(liquid limit less than 50)*	Inorganic	ML	Inorganic Silts of Low to Medium Plasticity, Rock Flour, or Clayey Silts With Slight Plasticity
			CL	Inorganic Clays of Low to Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean Clays
		Organic	OL	Organic Silts and Organic Silty Clays of Low Plasticity
	Silts and Clays *(liquid limit 50 or more)*	Inorganic	CH	Inorganic Clays of Medium to High Plasticity, Sandy Fat Clay, Gravelly Fat Clay
			MH	Inorganic Silts, Micaceous or Diatomaceous Fine Sands or Silty Soils, Elastic Silt
		Organic	OH	Organic Clays of Medium to High Plasticity, Organic Silts
Highly Organic Soils	Primarily organic matter, dark in color, and organic odor		PT	Peat, Humus, Swamp Soils with High Organic Content (See D 4427-92)

SAMPLE TYPES

- * Sample Not Recovered
- 2" O.D. Split Spoon Sample with 140 lb. Hammer (Standard Penetration Test - SPT)
- 2.5" O.D. Split Spoon Sample with 300 lb. Hammer (Non-Standard)
- 3" O.D. Split Spoon Samples with 300 lb. Hammer (Non-Standard)
- Sonic Coring Run
- 3" O.D. Shelby Tube Sample
- Osterberg Sample
- Pitcher Barrel Sample
- 2.5" O.D. Thin Wall Tube Sample
- G Grab Sample
- Soil Coring Run

NOTES

1. Dual Symbols (symbols separated by a hyphen, i.e., SP-SM, slightly silty fine SAND) are used for soils with between 5 % and 12% fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.
2. Borderline symbols (symbols separated by a slash, i.e., CL/ML, silty CLAY/clayey SILT; GW/SW, sandy GRAVEL/gravelly SAND) indicate that the soil may fall into one of two possible basic groups.

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SOIL CLASSIFICATION AND LOG KEY

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FIG. C-1
Sheet 2 of 4

File: I:\Drafting\211\09869-002\21-1-09869-002 Fig. C-1 (1,2,3).dwg Date: 07-16-2003 Author: SAC

STRUCTURE

TERM	THICKNESS
Parting	0 to 1/16 inch
Seam	1/16 to 1/2 inch
Layer	> 1/2 inch
Lamination	< 6 mm, < 1/4 inch
Pocket	Irregular, < 1 foot

DESCRIPTION	CRITERIA
Stratified	Alternating layers
Interbedded	Alternating layers > 1/2 inch
Laminated	Alternating layers < 6 mm thick
Fractures	Breaks easily along definite fractured planes
Slickensided	Polished, glossy, striated fractured planes
Blocky, Diced	Easily breaks into small angular lumps
Lensed	Small pockets of differentiated soils
Homogenous	Same color and appearance throughout
Sheared	Disturbed texture, mix of strengths

DISCONTINUITY SYMBOLS FOR SONIC LOGS

	Discrete Shear		Discrete Fracture
	Sheared Zone		Fracture Zone
	Discrete Slickenside		Deformed Zone
	Closely Slickensided Zone (2.5- to 8-inch spacing)	CL	Core Loss
	Very Close Slickensided Zone (0.75- to 2.5-inch spacing)	B15	Bedding and Angle of Orientation (degrees)
	Extremely Close Slickensided Zone (less than 0.75-inch spacing)	25	Angle of Zone of Discontinuities (degrees)

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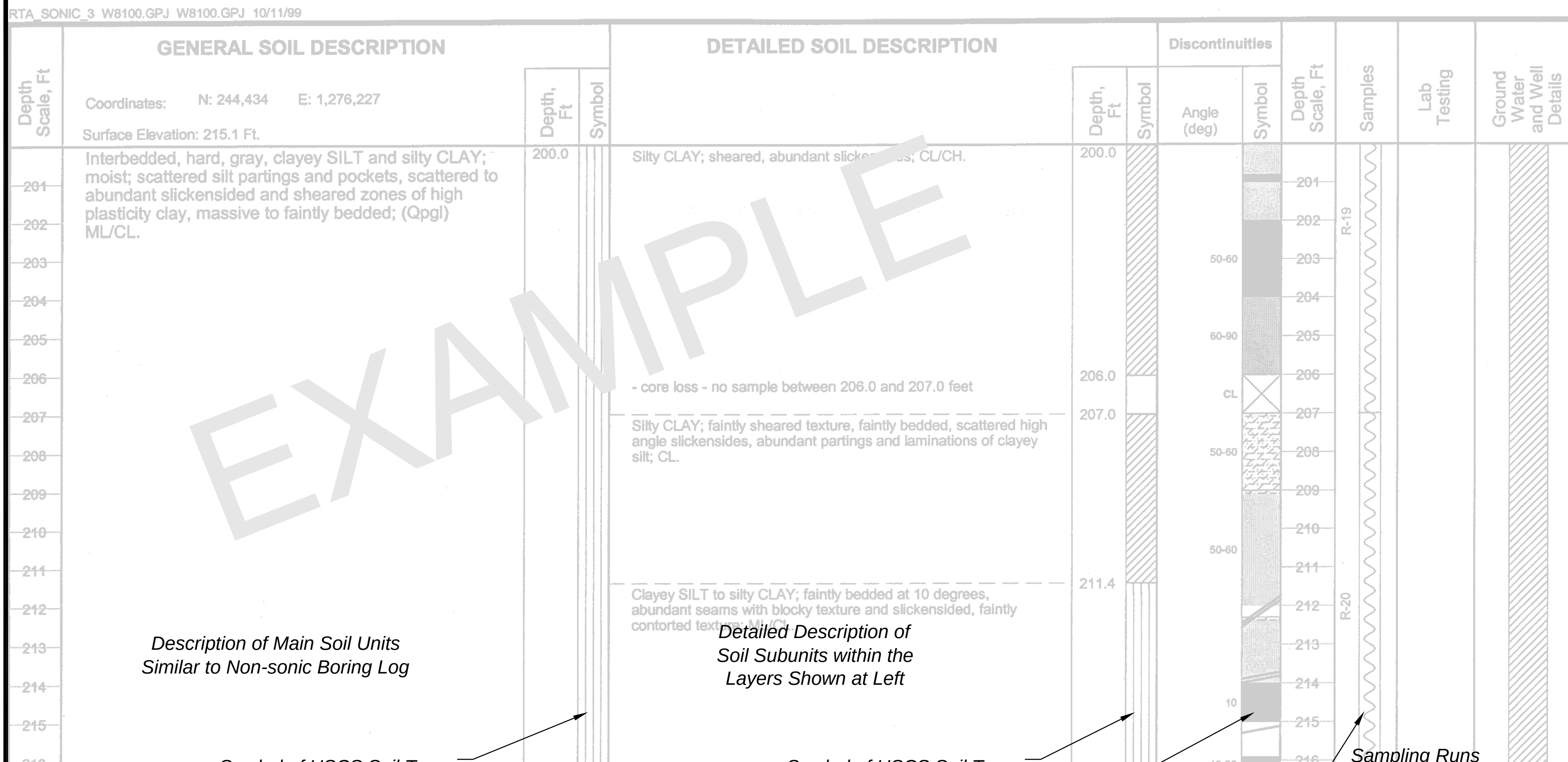
FIG. C-1
Sheet 3 of 4

File: I:\Drafting\211\09869-002\21-1-09869-002 Fig. C-1 (4).dwg Date: 07-16-2003 Author: SAC



Description of Main Soil Units Similar to Non-sonic Boring Log

Detailed Description of Soil Subunits within the Layers Shown at Left

Symbol of USCS Soil Type for Main Soil Units

Symbol of USCS Soil Type for Soil Subunits

Sampling Runs and Run Numbers

Symbols Showing Core Loss and Depth, Type, and Angle of Discontinuities (see sheet 3 of 4)

Explanation of Sonic and Rotary Core Logs

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SOIL CLASSIFICATION AND LOG KEY

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FIG. C-1
Sheet 4 of 4

FIG. C-1
Sheet 4 of 4

GEOLOGIC UNIT DESCRIPTIONS

HOLOCENE DEPOSITS

f	FILL: Fill placed by humans, both engineered and nonengineered Various materials, including debris; cobbles and boulders common; commonly dense or stiff if engineered, but very loose to dense or very soft to stiff if nonengineered.

QUATERNARY VASHON DEPOSITS

Qvro	RECESSIONAL OUTWASH DEPOSITS: Glaciofluvial sediment deposited as glacial ice retreated Clean to silty Sand, gravelly Sand, sandy Gravel; cobbles and boulders common; loose to very dense.
Qvrl	RECESSIONAL LACUSTRINE DEPOSITS: Glaciolacustrine fine-grained sediment deposited in depressions during retreat or wastage of the glacial ice sheet. Silt and fine Sand, locally clayey; very soft to very stiff.
Qvi	ICE-CONTACT DEPOSITS: Glacial deposits of diverse grain sizes deposited next to ice during wastage of the glacial ice sheet. Stratified to irregular bodies of Gravel, Sand, Silt, and Clay; loose to dense.
Qvt	TILL: Lodgment till laid down along the base of the glacial ice Gravelly silty Sand, silty gravelly Sand ("hardpan"); cobbles and boulders common; very dense.
Qvd	TILL-LIKE DEPOSITS (DIAMICT): Glacial deposit intermediate between till and outwash; subglacially reworked Silty gravelly Sand, silty Sand, sandy Gravel; highly variable over short distances; cobbles and boulders common; dense to very dense.
Qva	ADVANCE OUTWASH: Glaciofluvial sediment deposited as the glacial ice advanced through the Puget Lowland Clean to silty Sand, gravelly Sand, sandy Gravel; dense to very dense.
Qvlc	GLACIOLACUSTRINE DEPOSITS: Fined-grained glacial flour deposited in proglacial lake in Puget Lowland Silty clay, Clayey Silt, with interbeds of Silt and fine Sand; locally laminated; scattered organic fragments near base; hard or dense to very dense.

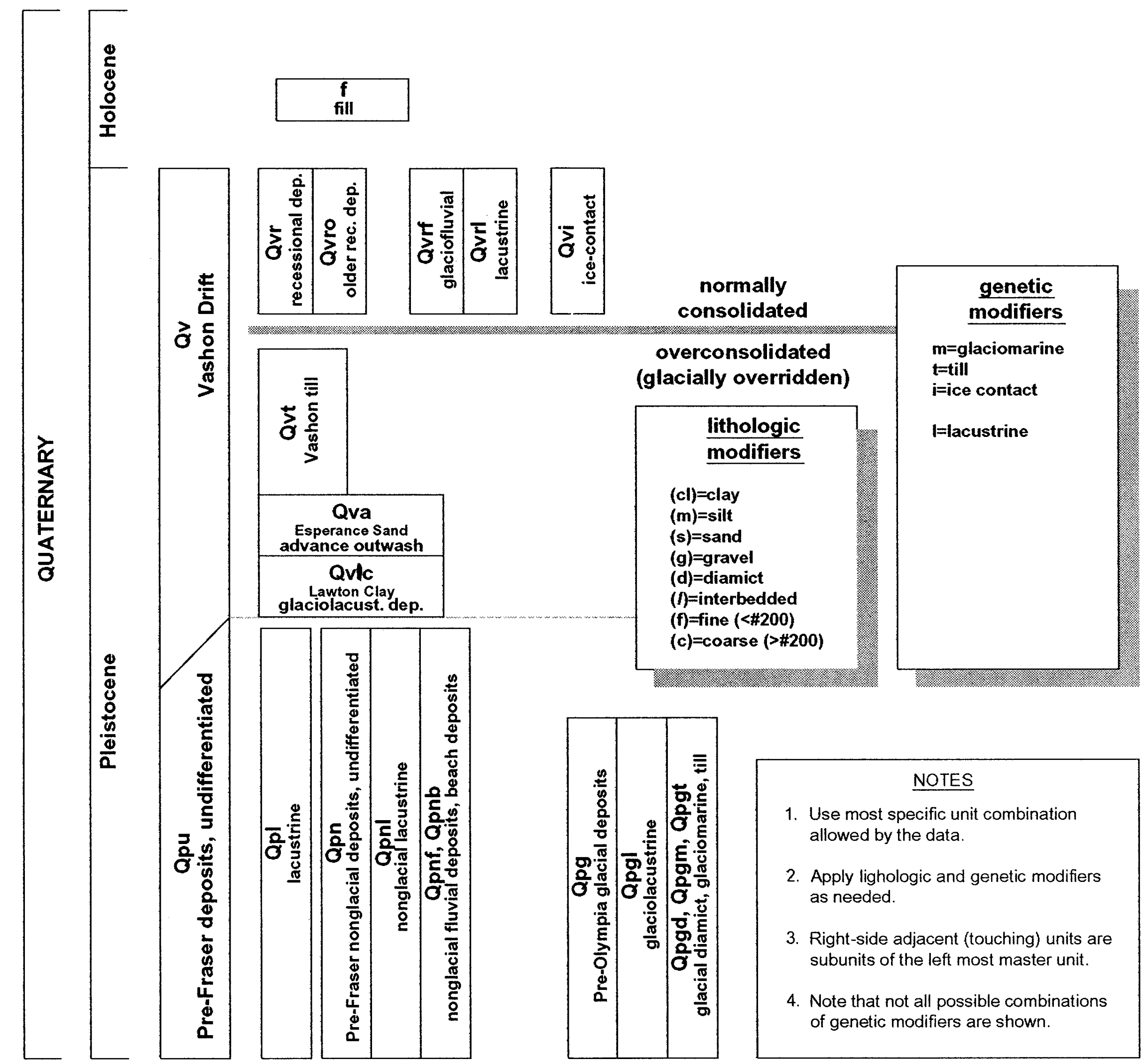
QUATERNARY PRE-VASHON DEPOSITS

Qpnf	FLUVIAL DEPOSITS: Alluvial deposits of rivers and creeks Clean to silty Sand, gravelly Sand, sandy Gravel; very dense.
Qpnl	LACUSTRINE DEPOSITS: Fine-grained lake deposits in depressions, large and small Fine sandy Silt, silty fine Sand, clayey Silt; scattered to abundant fine organics; dense to very dense or very stiff to hard.
Qpgo	OUTWASH: Glaciofluvial sediment deposited as the glacial ice advanced through the Puget Lowland Clean to silty Sand, gravelly Sand, sandy Gravel; very dense.
Qpgl	GLACIOLACUSTRINE DEPOSITS: Fine-grained glacial flour deposited in proglacial lake in Puget Lowland Silty Clay, clayey Silt, with interbeds of Silt and fine Sand; very stiff to hard or very dense.
Qpgt	TILL: Lodgement till laid down along the base of the glacial ice. Gravelly, silty Sand, silty gravelly Sand ("hardpan"); cobbles and boulders common; very dense,
Qpgd	TILL-LIKE DEPOSITS (DIAMICT): Glacial deposits intermediate between till and outwash; subglacially reworked. Silty gravelly Sand, silty Sand, sandy Gravel; highly variable over short distances; cobbles and boulders common; very dense.
Qpgm	GLACIOMARINE DEPOSITS: Till-like deposit with clayey matrix deposited in proglacial lake by icebergs, floating ice, and gravity currents. Heterogenous and variable mixture of Clay, Silt, Sand, and Gravel; rare shells; cobbles and boulders common; very dense or hard.

NOTE

The description of each geologic unit includes only general information regarding the environment of deposition and basic soil characteristics.

GEOLOGIC UNIT EXPLANATION FOR THE PROPOSED BRIGHTWATER TREATMENT PLANT AT THE SR-9 SITE



NOTE

Figure adapted from "Master List of Geologic Units for the Brightwater Project Area, Jan. 2003" prepared and provided by the UW Seattle-Area Geologic Mapping Project 12-19-02 Version.

Brightwater Treatment Plant
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GEOLOGIC UNIT EXPLANATION AND DESCRIPTIONS

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FIG. C-2

File: I:\Drafting\211\09869-002\21-1-09869-002 Geologic Units.dwg Date: 07-16-2003 Author: SAC

GENERAL SOIL DESCRIPTION

Coordinates: N: 618,046 E: 1,646,838

Surface Elevation: 158.6 Ft. Datum: NAVD88

Depth, Ft	General Soil Description	Detailed Soil Description	Samples	Lab Testing
0 – 1.5	Dense, gray, crushed rock.			
1.5 – 3.0	Medium dense, brown, gravelly, silty SAND; moist; with metal debris; (f) SM.			
3.0 – 20.0	Medium dense, brown, gravelly, silty SAND; moist; SM. - Soil logs between 0 and 20 feet provided by CDM who observed soil cuttings. Hole was cased to 20 feet prior to S&W being on site.			
20.0 – 22.0	Medium dense, brown, sandy GRAVEL, trace of silt; moist to wet; scattered cobbles to 7 inches in diameter; (Qvro) GW		R-1	wc=6.9%
22.0 – 23.5	Medium dense, brown, slightly clayey to clayey, fine sandy SILT, trace of fine gravel; moist to wet; iron oxide staining; (Qvro) ML.		R-1	wc=23.8%; wc=18.2%; LL=0%; PL=0%; wc=12.7%
23.5 – 49.5	Dense to very dense, gray, silty, fine to medium SAND, trace of gravel, grading with depth to silty, gravelly SAND; moist; locally trace of clay; (Qvd) SM.	- seam of fine sandy silt at 36 feet; ML. - seam of slightly silty, fine to medium SAND at 48 feet	R-2, R-3, R-4	wc=11.9% (30 ft); wc=10.7% (35 ft); wc=10.3%, wc=6.1%, wc=7.1% (40 ft); wc=7.7% (45 ft)

Ground Water and Well Details: 5/7/2003; 5/7/2003 [3]; 5/7/2003 [4]

Water levels of VWPs 2 and 5 are above ground. See note at end of log.

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of symbols and definitions.
5. USCS designation is based on visual-manual classification and selected laboratory index testing.
6. Relative densities and consistencies indicated in the descriptions are inferred from drill action, sample review, and conditions encountered in nearby boreholes.

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LOG OF BORING PB-12

July 2003 21-1-09869-001

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FIG. C-3
Sheet 1 of 11

Coordinates: N: 618,046 E: 1,646,838

Surface Elevation: 158.6 Ft. Datum: NAVD88

GENERAL SOIL DESCRIPTION

Description	Depth, Ft
Very dense, gray, slightly clayey, gravelly, silty SAND to silty, gravelly SAND, trace of clay; moist to wet; interbedded with layers of slightly silty, gravelly SAND, scattered cobbles; (Qvd) SM/SP-SM.	
Hard, gray and gray-brown, silty CLAY to very dense, clayey, silty SAND; moist; organic odor; (Qpgl) CL/SM.	88.5
Very dense, gray, slightly silty to silty, fine SAND; wet; scattered organics, with layer of silty clay; (Qpgl) SM/SP-SM.	94.7

DETAILED SOIL DESCRIPTION

Description	Depth, Ft
Slightly clayey, gravelly, silty SAND; SM.	
Silty, gravelly SAND, trace of clay; moist; SM. - 4-inch-thick layer of silty sand, trace of clay, at 53.5 feet	52.0
Slightly silty to silty, gravelly SAND; moist; SP-SM.	60.5
Slightly gravelly to gravelly, silty SAND, trace of clay; moist; SM. - 3-inch-thick layer of slightly silty SAND	64.8
Slightly silty, gravelly SAND; moist to wet; scattered silty layers; SP-SM/SM. - seam of gravelly, silty SAND	73.0
Clayey, silty, gravelly SAND; moist; SM.	79.2
Slightly silty, fine SAND; wet SP-SW.	80.7
Gravelly, silty, clayey SAND; moist; SC.	81.0
Slightly silty, gravelly SAND; moist; SP-SM.	83.0
Very dense, gray, silty, gravelly SAND, trace of clay; moist; scattered organic fragments; SM.	85.0
Clayey, silty SAND; moist; laminated; SM. - gravelly seam inclined at 30 to 40 degrees	88.5
Fine sandy, clayey SILT; moist; laminated; ML.	90.0
Gray to gray-brown, silty CLAY; moist; massive; CL/CH. - Seam of wet, silty, fine SAND to clayey SILT at 94.6 feet.	91.0
Silty, fine SAND; wet; SM.	94.7
Slightly silty, fine SAND; wet; SP-SM	99.0

Discontinuities

Angle (deg)	Depth
35	~89

Samples and Lab Testing

Sample	Lab Testing
R-5	wc=9.7% wc=8.8% wc=10.2%
R-6	wc=9.4% wc=10.4% wc=12.0% wc=7.8%
R-7	wc=10.9% wc=9.4%
R-8	wc=9.1% wc=10.2% LL=17% PL=16% wc=12.6%
R-9	wc=10.6% LL=0% PL=0% wc=18.7% wc=20.6%
R-10	wc=22.3% wc=21.2% wc=22.5%

Depth Scale, Ft: 55, 60, 65, 70, 75, 80, 85, 90, 95

Ground Water and Well Details

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of symbols and definitions.
5. USCS designation is based on visual-manual classification and selected laboratory index testing.
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Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

LOG OF BORING PB-12

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SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-3
Sheet 2 of 11

GENERAL SOIL DESCRIPTION

Coordinates: N: 618,046 E: 1,646,838

Surface Elevation: 158.6 Ft. Datum: NAVD88

Depth, Ft	General Soil Description
103.0	Very dense, gray, slightly silty SAND, trace of gravel, to gravelly SAND and sandy GRAVEL; wet; scattered to abundant cobbles; (Qpgo) SP-SM/GW.
	- observation during drilling: heaving problems between 125 and 130 feet, more clean-out passes required; see Note 4 on Sheet 11 for artesian groundwater description.
	- soil heave and 1 to 2 gpm flow observed between 125 and 150 feet while removing core barrel
126.0	Very dense, gray, silty SAND, trace of clay, to very stiff, silty, clayey SAND; wet; scattered wood fragments; (Qpgd) SM.
129.0	Very dense, gray, slightly silty, gravelly SAND, grading with depth to silty, fine SAND to fine sandy SILT; moist to wet; (Qpgo) SM/SP-SM.

DETAILED SOIL DESCRIPTION

Depth, Ft	Detailed Soil Description
99.3	Slightly silty to silty, fine SAND; wet; SP-SM/SM.
101.2	Silty CLAY, trace of fine sand; moist; slightly laminated to massive; CL.
102.2	Silty, fine SAND; wet; SM.
103.0	Slightly silty, fine to medium SAND; moist; scattered gravel; SP-SM.
104.7	Silty, clayey SAND to slightly clayey, silty SAND; moist to wet; massive to bedded; SC/SM.
108.0	Slightly silty, gravelly SAND to sandy, cobbly GRAVEL; wet; GW-GM/SW-SM.
110.0	Silty, fine to medium SAND; wet; trace of clay locally; SM.
111.6	Clean to slightly silty, slightly fine gravelly, fine to medium SAND; wet; SP-SM/SP.
115.8	Gravelly SAND, trace of silt; wet; SP.
116.2	Gray, slightly silty, slightly gravelly to gravelly SAND; wet; SP-SM.
119.0	Silty SAND, trace of gravel and silt; wet; SP.
126.0	Clayey, silty SAND to sandy, silty CLAY; moist; SM/CL.
126.7	Silty, clayey SAND to clayey, silty SAND, trace of fine gravel; moist; SC/SM.
128.0	Silty, fine SAND, trace of clay; moist; scattered wood fragments; SM.
129.0	Silty, fine to medium SAND; wet; scattered silt layers; SP-SM/SM.
133.5	Silty, fine to medium SAND; wet; scattered wood fragments; SM.
137.5	Silty, fine to medium SAND, trace of gravel; wet; scattered soil clasts or soft rock fragments, scattered organic clasts; SM.
140.0	Silty, fine to medium SAND, trace of gravel; moist to wet; SM.
141.0	Silty, gravelly SAND; moist; SM.
143.0	Silty, fine SAND; moist to wet; SM.

Discontinuities: Angle (deg) | Symbol

Depth Scale, Ft: 105, 110, 115, 120, 125, 130, 135, 140, 145

Samples: R-11, R-12, R-13, R-14, R-15

Lab Testing: wc=28.9%, LL=40%, PL=25%, wc=17.8%, wc=5.2%, wc=4.2%, wc=17.3%, wc=7.7%, wc=7.1%, wc=8.9%, wc=6.3%, wc=11.3%, wc=19.7%, wc=22.1%, wc=8.4%, wc=9.6%, wc=15.5%, wc=13.7%, wc=15.0%, wc=18.4%, wc=16.3%

Ground Water and Well Details

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
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Woodinville, Washington

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FIG. C-3
Sheet 3 of 11

FIG. C-3
Sheet 3 of 11

GENERAL SOIL DESCRIPTION

Coordinates: N: 618,046 E: 1,646,838

Surface Elevation: 158.6 Ft. Datum: NAVD88

Depth, Ft	General Soil Description
151.0	Very dense, gray, silty, fine SAND to clayey, silty, fine SAND; moist; and hard silty CLAY; scattered fine organics and organic-rich seams; (Qpgl) SM/CL.
158.1	Very dense, gray, silty, gravelly SAND to silty SAND, trace of gravel; moist to wet; locally trace of clay to clayey; (Qpgt) SM.
175.0	Very dense, gray, slightly gravelly to gravelly, silty SAND; moist to wet; scattered cobbles, scattered clayey seams; (Qpgo) SM.
180.0	Very dense, gray, silty, gravelly SAND to slightly clayey, fine sandy SILT, trace of gravel; moist; (Qpgd) SM/ML. - observation during drilling: drillers said there may be some layers of clean sand and gravel
195.0	Hard, gray, slightly fine sandy, clayey SILT to slightly clayey, fine sandy SILT; moist; scattered seams of silty clay, scattered dark gray organic seams, locally trace of gravel; (Qpnl) ML.

DETAILED SOIL DESCRIPTION

Depth, Ft	Detailed Soil Description
151.0	Clayey, silty, fine SAND; moist; interbeds of silty, fine sand and silty clay; SM/CL
153.0	Silty, fine to medium SAND; moist; scattered organics; SM.
155.1	Interbedded, slightly clayey to clayey SILT and silty, fine SAND; moist; laminated to bedded; scattered organics; SM/ML.
156.4	Silty CLAY, trace of fine sand; moist; bedded with abundant seams of brown, organic-rich, clayey, fine to medium sand; CL.
158.1	Slightly clayey, silty SAND, trace of gravel; to silty, clayey SAND; moist; SM/SC.
160.1	Silty, gravelly SAND; moist; locally trace of gravel; SM.
168.5	Slightly clayey, silty, fine SAND; moist; scattered organics; SM.
170.0	Silty SAND, trace of gravel; moist to wet; SM. - 4-inch-diameter cobble
174.0	- scattered organics
175.0	Slightly clayey, silty SAND, trace of fine gravel; moist; SM.
175.5	Gravel and cobbles; GP.
177.5	Gravelly, silty SAND; moist to wet; SM. Slightly gravelly to gravelly, silty SAND; moist to wet; scattered cobbles, scattered clayey seams; SM.
180.0	Silty, gravelly SAND; moist; trace of clay; SM.
184.0	No sample recovered.
193.0	Slightly clayey, gravelly, silty SAND; moist; SM.
193.4	Slightly clayey, fine sandy SILT, trace of gravel; moist; ML.
195.0	

Discontinuities

Angle (deg)	Symbol
CL	

Samples and Lab Testing

Sample	Lab Testing
R-16	wc=15.1%; wc=14.6%; wc=16.7%; LL=28%; PL=17%; wc=13.7%
R-17	wc=10.5%; wc=8.5%
R-18	wc=9.1%; wc=10.6%; wc=12.6%
R-19	wc=7.9%; wc=8.2%; wc=6.5%
R-20	wc=18.1%; LL=24%; PL=19%; wc=20.1%; wc=18.6%

NOTES

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FIG. C-3
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FIG. C-3
Sheet 4 of 11

GENERAL SOIL DESCRIPTION

Coordinates: N: 618,046 E: 1,646,838

Surface Elevation: 158.6 Ft. Datum: NAVD88

Depth, Ft	General Soil Description
	Hard, gray, clayey SILT to sandy SILT; (Qpnl) ML (cont).
205.0	Very dense, gray, silty, fine SAND to slightly clayey, silty, fine SAND; moist; scattered seams of fine sandy, clayey silt; abundant organic fragments and organic-rich seams; abundant horizontal to high-angle clay seams; scattered clay fragments and slickensided clay clasts; (Qpnl) SM. - end of sonic core at 215 feet
215.0	Hard, gray, slightly fine sandy, slightly clayey to clayey SILT to silty CLAY; moist; with interbedded silty fine sand; (Qpnl) CL/ML. - observation during drilling: had to clean out about 20 feet of slough prior to starting wireline core at 215 feet; organics in cuttings

DETAILED SOIL DESCRIPTION

Depth, Ft	Detailed Soil Description	Discontinuities Angle (deg)
	- Micaceous; scattered to abundant organic seams; scattered pockets and high-angle seams of silty clay, clayey silt, and fine sand.	
205.0	Silty, fine SAND; moist; abundant organics, scattered to abundant clay fragments and slickensided clay clasts; SM.	
206.8	Slightly clayey, silty, fine SAND; moist; with 60 degree clay seam; SM.	60
210.1	Silty fine SAND; moist; with clay infilling at 70 degrees; SM.	70
212.1	Clayey, silty SAND; wet; SM. - 1/2-inch-thick clay seam - 1-1/2-inch-thick clay seam	
215.0	Silty CLAY to slightly clayey, silty, fine SAND; CL/SM.	
217.8	No soil recovery.	CL
220.0	Fine sandy, silty CLAY; moist; with silty fine sand infilling, 40 degree fracture; CL.	40
221.8	No soil recovery.	CL
225.0	Silty, fine SAND; moist; SM.	
226.6	No soil recovery.	CL
233.4	Silty CLAY, moist; CL. - Disturbed zone; no laminations.	
235.0	No soil recovery.	CL
240.5	Silty CLAY; moist; CL. -1/2-inch-wide, sand-filled fracture at 60 degrees	60
242.6	No soil recovery.	CL
243.0	Soft, clayey SILT (slough)	
244.8	No soil recovery.	

Samples and Lab Testing

Sample	Lab Testing
R-21	wc=17.4%; wc=18.9%; wc=24.5%; LL=25%; PL=22%; wc=20.4%; wc=20.4%; wc=21.3%
R-22	wc=22.8%; wc=24.2%; wc=25.3%; wc=24.0%
R-23	wc=23.4%; LL=28%; wc=21.4%; PL=23%; wc=22.7%
R-24	wc=27.8%
R-25	wc=23.1%
R-26	wc=22.1%

Depth Scale, Ft: 205, 210, 215, 220, 225, 230, 235, 240, 245

Ground Water and Well Details

NOTES

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Geotechnical and Environmental Consultants

FIG. C-3
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Depth Scale, Ft	GENERAL SOIL DESCRIPTION Coordinates: N: 618,046 E: 1,646,838 Surface Elevation: 158.6 Ft. Datum: NAVD88	Depth, Ft	DETAILED SOIL DESCRIPTION	Depth, Ft	Discontinuities Angle (deg)	Depth Scale, Ft	Samples	Lab Testing
	Hard, gray, slightly fine sandy, slightly clayey to clayey SILT to silty CLAY; (Qpnl) CL/ML (cont.).		No soil recovery (cont.).		CL		R-27	
255	- observation during drilling: drillers said run was soft					255	R-28	
			Silty, fine SAND; moist; SM.	257.0				wc=21.8%
			No soil recovery.	258.6	CL		R-29	
260		261.0	- Silty, fine SAND; wet; trace organics; SM.	261.0		260		
	Hard, gray, slightly clayey to clayey, fine sandy SILT and slightly clayey, silty, fine SAND; moist to wet; scattered to abundant organics, with interbeds of very dense, gray, silty, fine sand and hard, gray silty clay; (Qpnl) ML/SM.		Sandy, clayey SILT; moist; ML.	261.6			R-30	wc=21.3% LL=25% PL=19% wc=19.2%
			- Seam of silty, fine SAND.	264.6	CL		R-31	
265			No soil recovery.	265.0		265	R-32	
			Slightly clayey, fine sandy SILT; moist; abundant organics; ML.				R-33	wc=21.4% wc=23.1%
	- observation during drilling: washed out zones may be silt and soft drilling; drillers did runs "almost dry" to try and preserve samples; core barrel sanded in (?) at 276 feet; driller said Run 36 was soft at bottom; organics in cuttings at 281 feet; Runs 37, 38, and 40 drilled soft; trace organics in cuttings at 295 feet		No soil recovery.	269.8	CL			
270			Slightly clayey, fine sandy SILT; moist; ML.	270.5	65	270	R-34	wc=19.3%
			- Organic layer, 1/2 inch thick.					wc=21.7%
			- 1-inch-wide, sand-filled fracture at 65 degrees.	273.3				
			Silty CLAY; moist; CL	273.6			R-35	
275			Slightly clayey, fine sandy SILT; moist; ML	274.5	CL	275		
			No soil recovery.	276.0				wc=23.8%
			Slightly clayey, fine sandy SILT; moist; ML				R-36	
			No soil recovery.	278.6	CL			
280			Slightly clayey, silty, fine SAND; moist; SM	281.0		280		
			-seam of organic, clayey, silty, fine sand				R-37	wc=22.0%
			- Seam of organic, clayey, silty, fine SAND					
			Silty, fine SAND; wet; SM.	284.6				wc=23.4%
285			- Clayey, silty, fine SAND; wet; SM.	285.3		285	R-38	wc=24.1% LL=26% PL=16%
			Silty, fine sandy CLAY; moist; SM.	286.9	CL			
			No soil recovery.	288.0				
			Clayey, silty, fine SAND; wet; SM.				R-39	
290			- Organic, sandy silt seam			290		wc=24.1%
			No soil recovery.	291.5	CL			
			Silty, clayey SAND; moist to wet; SC.	292.0				wc=20.2%
295			Silty, fine SAND; SM.	294.8		295	R-40	wc=23.5%
			No soil recovery.	295.5	CL			
			Slightly clayey, silty, fine SAND; wet; SM.	297.0				
			Clayey, fine sandy SILT; moist; ML.	298.0				wc=22.8%

NOTES

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FIG. C-3
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GENERAL SOIL DESCRIPTION

Coordinates: N: 618,046 E: 1,646,838

Surface Elevation: 158.6 Ft. Datum: NAVD88

Hard, gray, slightly clayey to clayey, fine sandy SILT and slightly clayey, silty, fine SAND; (Qpnl) ML/SM (cont.).

- observation during drilling: driller didn't lock in core barrel and lost Runs 43 and 44; trace organics in cuttings at 330 and 340 feet; drilling consistent from about 345 to 350 feet; casing stuck in hole and sample tube sanded in at 365 feet; driller said about 1 foot of sample dropped out of tube in Run 52.

DETAILED SOIL DESCRIPTION

Depth, Ft	Description
300.3	-seam of organic, fine sandy silt
301.3	Silty, fine SAND; moist; SM.
302.2	Clayey, fine sandy SILT; moist; ML.
302.5	Silty, fine SAND; moist; SM.
303.8	Fine sandy SILT; wet; organic seam; ML.
304.6	Silty, fine SAND; wet; SM.
305.2	Silty CLAY and silty, fine SAND; moist; CL/SM.
306.6	Silty, clayey, fine SAND; moist; SM.
307.2	- Seam of organic, fine sandy silt.
307.9	Slightly clayey, silty, fine SAND; wet; SC/SM.
	Silty, clayey, fine SAND; SM.
	No soil recovery.
315.0	Slightly clayey, silty, fine SAND to silty CLAY, trace of fine sand; moist; SM/CL. - 1-inch seam of silty, fine SAND - 1-inch seam of silty, fine SAND - 1-inch seam of silty, fine SAND
323.8	Silty CLAY, trace of sand, and slightly fine sandy, clayey SILT; moist; CL/ML.
326.5	Silty CLAY; moist; CL.
327.4	No soil recovery.
328.0	Silty, fine SAND; wet; SM.
329.1	Clayey SILT, trace of sand, and silty, fine SAND; ML/SM.
334.2	Silty, fine SAND; wet; SM.
334.6	Silty, fine SAND, trace of clay; moist; with slightly clayey seams; SM.
336.2	Silty, fine SAND; wet; SM.
336.5	Clayey, fine sandy SILT; moist; ML.
338.9	Silty, fine SAND; wet; trace organics; SM.
339.2	Silty CLAY; moist; CL.

Discontinuities

Depth	Angle (deg)
~310–315	CL
~327	CL

Samples and Lab Testing

Depth Scale, Ft	Samples	Lab Testing
300	R-41	wc=21.8%
305	R-42	wc=25.0% LL=26% PL=17% wc=22.7%
310	R-43	
313	R-44	
315	R-45	wc=23.9%
320	R-46	wc=25.7%
325	R-47	wc=22.7%
328		wc=23.4%
330	R-48	wc=24.5%
335		wc=23.3% wc=23.8%
338	R-49	
340		wc=25.5% LL=29% PL=19%
345		wc=25.5% wc=27.0%
348	R-50	

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FIG. C-3
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FIG. C-3
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GENERAL SOIL DESCRIPTION

Coordinates: N: 618,046 E: 1,646,838

Surface Elevation: 158.6 Ft. Datum: NAVD88

Depth, Ft	General Soil Description
	Hard, gray, slightly clayey to clayey, fine sandy SILT and slightly clayey, silty, fine SAND; (Qpnl) ML/SM (cont.).
375.0	Hard, gray, fine sandy, clayey SILT to slightly fine sandy, silty CLAY; moist; massive to bedded; (Qpnl) ML/CL. - observation during drilling: driller thinks last 2 feet of Run 54 either washed out or dropped out; sample tube was stuck
390.5	Hard, gray, slightly fine sandy, clayey SILT to silty CLAY; moist; scattered seams of silty, fine sand and dark gray, fine sandy organic silt; (Qpnl) CL/ML.

DETAILED SOIL DESCRIPTION

Depth, Ft	Detailed Soil Description
350.3	Dark gray, fine sandy SILT; moist; organic seam; ML.
350.6	Clayey, fine sandy SILT; moist; ML. 1-inch layer silty CLAY; moist; CL. 1-inch layer silty CLAY; moist; CL.
356.8	Silty, fine SAND; wet; SM.
357.0	Slightly clayey, fine sandy SILT; moist; ML. - Bioturbation
360.7	- Seam of dark gray, organic, fine sandy SILT. Slightly clayey, silty, fine SAND; wet; SM.
362.6	Slightly clayey, silty, fine SAND; wet; SM.
363.3	Slightly clayey, fine sandy SILT; moist; ML. - Bioturbation.
366.8	No soil recovery.
368.0	Slightly clayey, fine sandy SILT; moist; ML.
369.8	Silty CLAY; moist; CL.
370.0	Slightly clayey, fine sandy SILT; moist; ML.
375.0	Fine sandy, clayey SILT; moist; ML.
376.0	Slightly fine sandy, clayey SILT; moist; ml.
377.7	No soil recovery.
379.0	Fine sandy, silty CLAY to clayey, silty, fine SAND; moist; CL/SM.
384.0	No soil recovery.
387.0	Slightly fine sandy, clayey SILT; moist ML.
390.5	- Seam of organic, fine sandy silt. Slightly fine sandy, clayey SILT to slightly fine sandy, silty CLAY; moist; ML/CL.

Discontinuities — Angle (deg): CL (at 366.8–368.0), CL (at 377.7–379.0), CL (at 384.0–387.0)

Depth Scale, Ft	Samples	Lab Testing
355	R-51	wc=22.7%
		wc=22.4%
360		wc=19.4%
365	R-52	
370		wc=21.4%
375	R-53	wc=19.8%
380		wc=18.5%
385	R-54	
390		wc=21.1% LL=27% PL=22%
395	R-55	wc=23.5%

Ground Water and Well Details

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GENERAL SOIL DESCRIPTION

Coordinates: N: 618,046 E: 1,646,838

Surface Elevation: 158.6 Ft. Datum: NAVD88

Depth, Ft	General Soil Description
	Hard, gray, slightly fine sandy, clayey SILT to silty CLAY, trace of fine sand; (Qpnl) ML/CL (cont.).
434.5	Hard, gray, silty CLAY, trace of sand and gravel, to slightly sandy, silty CLAY; moist; (Qpgm) CH. - observation during drilling: driller said it was dense at 440 feet
442.0	Very dense, gray, slightly clayey to clayey, silty, gravelly SAND grading to slightly fine gravelly, silty SAND, trace of clay; moist; scattered cobbles; (Qpgm)SM.

DETAILED SOIL DESCRIPTION

Depth, Ft	Detailed Soil Description	Discontinuities Angle (deg)
402.0	Silty CLAY to clayey SILT; moist; ML/CL.	
412.0	Silty CLAY; moist; massive to faintly laminated; CL.	
416.7	No soil recovery.	CL
417.0	Silty CLAY; moist; massive to faintly laminated; CL. - laminations 1/2 to 2 inches thick with trace of fine sand and organic clasts - organic clasts becoming scattered below 424 feet	
428.0	Silty CLAY; moist; scattered stringers of dark gray organics, 1/4- to 3/8-inch-thick laminations; CL.	
430.9	Silty CLAY: moist; trace of fine sand and organics; CL.	
434.5	Silty CLAY, trace of sand and gravel; moist; CH.	
435.5	Fine sandy SILT; moist; ML. - Contact of 50 degrees between gravelly CLAY and sandy SILT; ML.	50
436.4	Silty CLAY, trace of sand, to slightly sandy, silty CLAY; moist; CH. - 1-inch-thick seam of silty fine sand.	
442.0	Clayey, silty, gravelly SAND; moist; SM.	
444.0	Silty, gravelly SAND, trace of clay; moist; scattered cobbles; SM.	
444.5	Clayey, silty, gravelly SAND; moist; SM.	
445.4	No soil recovery.	CL
448.0	Slightly clayey, gravelly, silty SAND; moist; SM.	

Samples: R-56, R-57, R-58, R-59, R-60, R-61, R-62

Lab Testing: wc=22.3%, wc=23.4%, wc=23.9%, wc=26.4%, wc=25.9%, wc=26.6%, wc=30.5% LL=36% PL=24%, wc=26.2%, wc=10.5%, wc=29.0% LL=80% PL=22% wc=15.3%, wc=8.6%, wc=10.9%

Depth Scale, Ft: 405, 410, 415, 420, 425, 430, 435, 440, 445

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LOG OF BORING PB-12

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FIG. C-3
Sheet 9 of 11

FIG. C-3 Sheet 9 of 11

Depth Scale, Ft	GENERAL SOIL DESCRIPTION (Coordinates: N: 618,046 E: 1,646,838; Surface Elevation: 158.6 Ft. Datum: NAVD88)	Depth, Ft	DETAILED SOIL DESCRIPTION	Depth, Ft	Discontinuities Angle (deg)	Samples	Lab Testing
	Very dense, gray, slightly clayey to clayey, silty, gravelly SAND grading to slightly fine gravelly, silty SAND, trace of clay; (Qpgm) SM (cont.).		No soil recovery.	451.7	CL	R-63	
455	- observation during drilling: driller thinks sandy zones are washing out; drilling alternates from hard (on cobbles?) to soft; tube sanded in at 465 feet; Run 65 likely fell out of tube; driller said Run 66 was softer; driller thought there was a rock in front of the casing on Run 66, preventing the sample from being taken		- Silty, sandy GRAVEL; GM.	455.0			wc=8.4%
			No soil recovery.	457.0	CL	R-64	
460							wc=9.3%
			Slightly fine gravelly, silty SAND; moist; SM	464.0			
465			No soil recovery.	464.5	CL	R-65	
470							
			No soil recovery.	472.5	CL	R-66	
475							
480							wc=21.8%
	Hard, gray, clayey SILT, trace of sand, to sandy, clayey SILT; moist to wet; (Qpgm) ML.	482.5		482.5			
485			No soil recovery.	484.1	CL	R-67	
				487.0			
	Very dense, green-gray to gray-brown, silty, fine SAND to clayey, silty, fine SAND; scattered organic seams and wood; (Qpnl) SM.	488.4	Green-gray, clayey, silty, fine SAND; moist; SM.	488.4		R-68	
490			No soil recovery.	491.1	CL		wc=28.9% LL=38% PL=31%
	- observation during drilling: driller felt cobbles between about 490 and 491 feet; driller said drilling was getting softer from 500 to 501 feet		Green-gray, clayey, silty, fine SAND; moist; SM.	494.5			wc=19.9%
495			Gray-brown, clayey, silty, fine SAND; moist; SM.	495.1			wc=26.3%
			Fine sandy SILT; moist; organic layer; ML.	495.6			
			Wood.	497.0		R-69	
			No soil recovery.	497.3	CL		

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of symbols and definitions.
5. USCS designation is based on visual-manual classification and selected laboratory index testing.
6. Relative densities and consistencies indicated in the descriptions are inferred from drill action, sample review, and conditions encountered in nearby boreholes.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

LOG OF BORING PB-12

July 2003 21-1-09869-001

SHANNON & WILSON, INC.
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FIG. C-3
Sheet 10 of 11

Depth Scale, Ft	GENERAL SOIL DESCRIPTION Coordinates: N: 618,046 E: 1,646,838 Surface Elevation: 158.6 Ft. Datum: NAVD88	Depth, Ft	Symbol	DETAILED SOIL DESCRIPTION	Depth, Ft	Symbol	Discontinuities: Angle (deg)	Discontinuities: Symbol	Depth Scale, Ft	Samples	Lab Testing	Ground Water and Well Details
	BOTTOM OF BORING COMPLETED 4-5-2003	501.0			501.0							
505									505			
510									510			
515									515			
520									520			
525									525			
530									530			
535									535			
540									540			
545									545			

Notes:
1. Water levels for VWPs 2 and 5 were 15.6 and 7.9 feet, respectively, above the ground surface on 5/7/2003.
2. A 3-foot-diameter surface casing was installed from 0 to 20 feet. A 8 5/8-inch-diameter casing was used from 20 to 148 feet. A 7 5/8-inch-diameter casing was used from 148 to 215 feet.
3. Six-inch-diameter, sonic core sampling was performed from 20 to 215 feet. Four-inch-diameter wireline soil coring was completed from 215 to 501 feet. The wireline coring consisted of a 5-inch-diameter outer barrel and a 6-inch-diameter coring bit.
4. According to CDM, after reaching 215 feet with the sonic core, the driller tried to remove the 8 5/8-inch casing, which was at 148 feet. When the 8 5/8-inch casing was raised to 115 feet, there was an estimated 40 gallons per minute flow 7 feet above the ground surface. The casing was then pushed back down to a depth of 153 feet, and the artesian flow stopped. A temporary sanitary seal was placed in the 3-foot-diameter surface casing. CDM estimated that they collected 13 55-gallon drums of water.

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of symbols and definitions.
5. USCS designation is based on visual-manual classification and selected laboratory index testing.
6. Relative densities and consistencies indicated in the descriptions are inferred from drill action, sample review, and conditions encountered in nearby boreholes.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

LOG OF BORING PB-12

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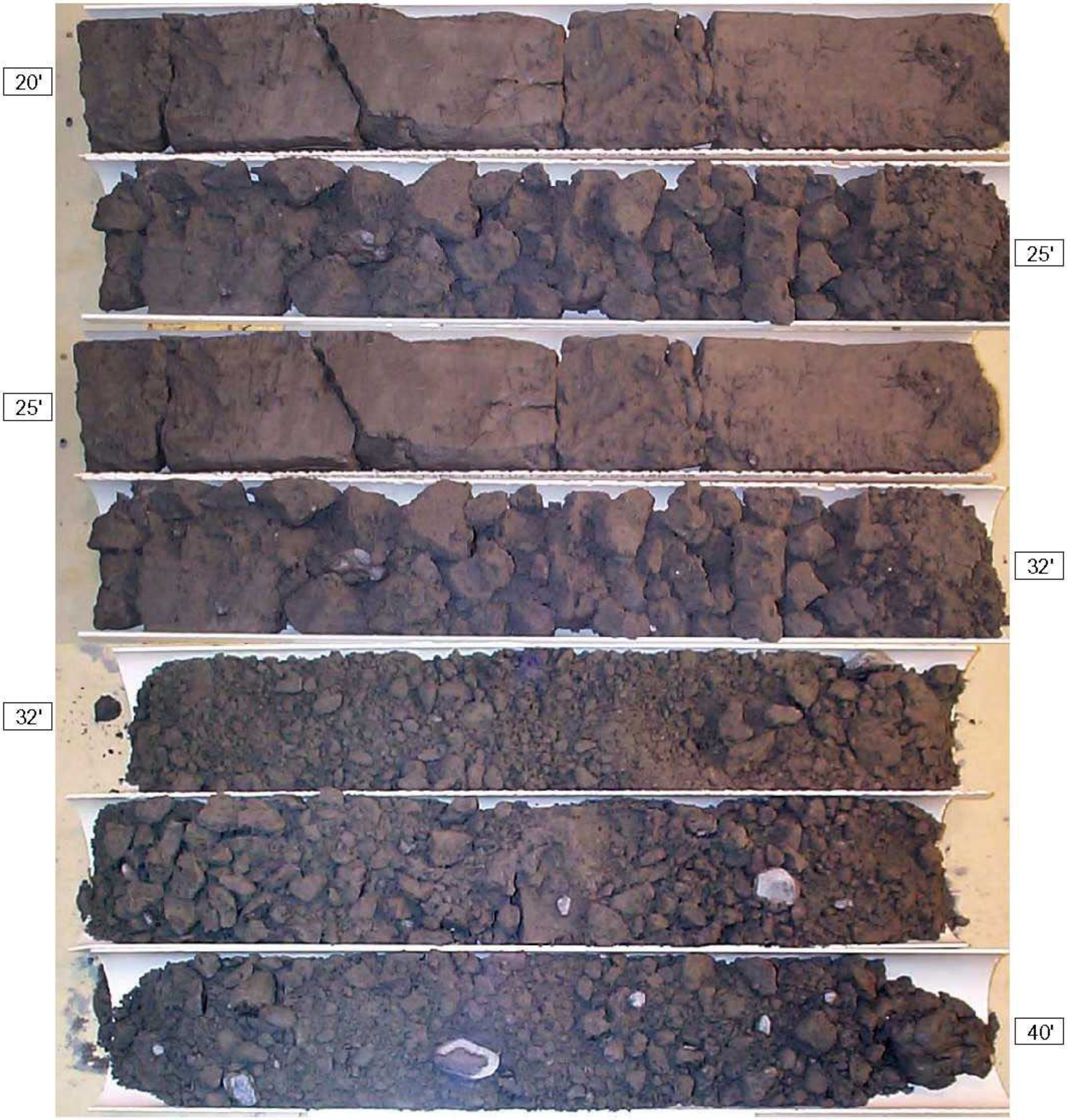
FIG. C-3
Sheet 11 of 11



NOTE

From 20 to 215 feet, 6-inch-diameter sonic core was recovered. From 215 to 501 feet, 4-inch-diameter wireline core was recovered.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

SOIL CORE PHOTOGRAPHS
BORING PB-12
20 TO 40 FEET

July 2003 21-1-09869-002

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FIG. C-4
Sheet 1 of 20

File: I:\Drafting\211\09869-002\21-1-09869-002 Soil Core.dwg Date: 07-16-2003 Author: SAC

40'

45'

50'

50'

55'

NOTE

From 20 to 215 feet, 6-inch-diameter sonic core was recovered. From 215 to 501 feet, 4-inch-diameter wireline core was recovered.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

SOIL CORE PHOTOGRAPHS
BORING PB-12
40 TO 55 FEET

July 2003 21-1-09869-002

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FIG. C-4
Sheet 2 of 20

File: I:\Drafting\211\09869-002\21-1-09869-002 Soil Core.dwg Date: 07-16-2003 Author: SAC

NOTE
From 20 to 215 feet, 6-inch-diameter sonic core was recovered. From 215 to 501 feet, 4-inch-diameter wireline core was recovered.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

SOIL CORE PHOTOGRAPHS
BORING PB-12
55 TO 73 FEET

July 2003 21-1-09869-002

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FIG. C-4
Sheet 3 of 20

File: I:\Drafting\211\09869-002\21-1-09869-002 Soil Core.dwg Date: 07-16-2003 Author: SAC

NOTE

From 20 to 215 feet, 6-inch-diameter sonic core was recovered. From 215 to 501 feet, 4-inch-diameter wireline core was recovered.

Brightwater Treatment Plant Route 9 Site Woodinville, Washington	
SOIL CORE PHOTOGRAPHS BORING PB-12 73 TO 90 FEET	
July 2003	21-1-09869-002
SHANNON & WILSON, INC. Geotechnical and Environmental Consultants	**FIG. C-4** Sheet 4 of 20

File: I:\Drafting\211\09869-002\21-1-09869-002 Soil Core.dwg Date: 07-16-2003 Author: SAC

NOTE

From 20 to 215 feet, 6-inch-diameter sonic core was recovered. From 215 to 501 feet, 4-inch-diameter wireline core was recovered.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

SOIL CORE PHOTOGRAPHS
BORING PB-12
90 TO 110 FEET

July 2003 21-1-09869-002

SHANNON & WILSON, INC.
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FIG. C-4
Sheet 5 of 20

NOTE

From 20 to 215 feet, 6-inch-diameter sonic core was recovered. From 215 to 501 feet, 4-inch-diameter wireline core was recovered.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

SOIL CORE PHOTOGRAPHS
BORING PB-12
110 TO 131 FEET

July 2003 21-1-09869-002

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FIG. C-4
Sheet 6 of 20

File: I:\Drafting\211\09869-002\21-1-09869-002 Soil Core.dwg Date: 07-16-2003 Author: SAC

131'

139'

147'

139'

147'

153'

NOTE
From 20 to 215 feet, 6-inch-diameter sonic core was recovered. From 215 to 501 feet, 4-inch-diameter wireline core was recovered.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

SOIL CORE PHOTOGRAPHS
BORING PB-12
131 TO 153 FEET

July 2003 21-1-09869-002

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FIG. C-4
Sheet 7 of 20

File: I:\Drafting\211\09869-002\21-1-09869-002 Soil Core.dwg Date: 07-16-2003 Author: SAC

153'

160'

160'

167'

167'

175'

NOTE
From 20 to 215 feet, 6-inch-diameter sonic core was recovered. From 215 to 501 feet, 4-inch-diameter wireline core was recovered.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

SOIL CORE PHOTOGRAPHS
BORING PB-12
153 TO 175 FEET

July 2003 21-1-09869-002

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FIG. C-4
Sheet 8 of 20

File: I:\Drafting\211\09869-002\21-1-09869-002 Soil Core.dwg Date: 07-16-2003 Author: SAC

NOTE

From 20 to 215 feet, 6-inch-diameter sonic core was recovered. From 215 to 501 feet, 4-inch-diameter wireline core was recovered.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

SOIL CORE PHOTOGRAPHS
BORING PB-12
175 TO 200 FEET

July 2003 21-1-09869-002

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FIG. C-4
Sheet 9 of 20

File: I:\Drafting\211\09869-002\21-1-09869-002 Soil Core.dwg Date: 07-16-2003 Author: SAC

200'

205'

205'

209'

209'

215'

End of Sonic Core

NOTE
From 20 to 215 feet, 6-inch-diameter sonic core was recovered. From 215 to 501 feet, 4-inch-diameter wireline core was recovered.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

SOIL CORE PHOTOGRAPHS
BORING PB-12
200 TO 215 FEET

July 2003 | 21-1-09869-002

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FIG. C-4
Sheet 10 of 20

Start of Wireline Core

215' 220'

220' 225'

225' 233'

233'

253'

257'

265'

NOTE
From 20 to 215 feet, 6-inch-diameter sonic core was recovered. From 215 to 501 feet, 4-inch-diameter wireline core was recovered.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

SOIL CORE PHOTOGRAPHS
BORING PB-12
215 TO 265 FEET

July 2003 21-1-09869-002

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FIG. C-4

File: I:\Drafting\211\09869-002\21-1-09869-002 Soil Core.dwg Date: 07-16-2003 Author: SAC

265' 267'

269.8' 272'

272.5'

276' 281'

281' 284'

284' 288'

292'

NOTE

From 20 to 215 feet, 6-inch-diameter sonic core was recovered. From 215 to 501 feet, 4-inch-diameter wireline core was recovered.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

SOIL CORE PHOTOGRAPHS
BORING PB-12
265 TO 292 FEET

July 2003 21-1-09869-002

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FIG. C-4
Sheet 12 of 20

File: I:\Drafting\211\09869-002\21-1-09869-002 Soil Core.dwg Date: 07-16-2003 Author: SAC

NOTE

From 20 to 215 feet, 6-inch-diameter sonic core was recovered. From 215 to 501 feet, 4-inch-diameter wireline core was recovered.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

SOIL CORE PHOTOGRAPHS
BORING PB-12
292 TO 323 FEET

July 2003 21-1-09869-002

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FIG. C-4
Sheet 13 of 20

File: I:\Drafting\211\09869-002\21-1-09869-002 Soil Core.dwg Date: 07-16-2003 Author: SAC

NOTE
From 20 to 215 feet, 6-inch-diameter sonic core was recovered. From 215 to 501 feet, 4-inch-diameter wireline core was recovered.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

SOIL CORE PHOTOGRAPHS
BORING PB-12
323 TO 345.5 FEET

July 2003 21-1-09869-002

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FIG. C-4
Sheet 14 of 20

File: I:\Drafting\211\09869-002\21-1-09869-002 Soil Core.dwg Date: 07-16-2003 Author: SAC

NOTE
From 20 to 215 feet, 6-inch-diameter sonic core was recovered. From 215 to 501 feet, 4-inch-diameter wireline core was recovered.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

SOIL CORE PHOTOGRAPHS
BORING PB-12
345.5 TO 368 FEET

July 2003 | 21-1-09869-002

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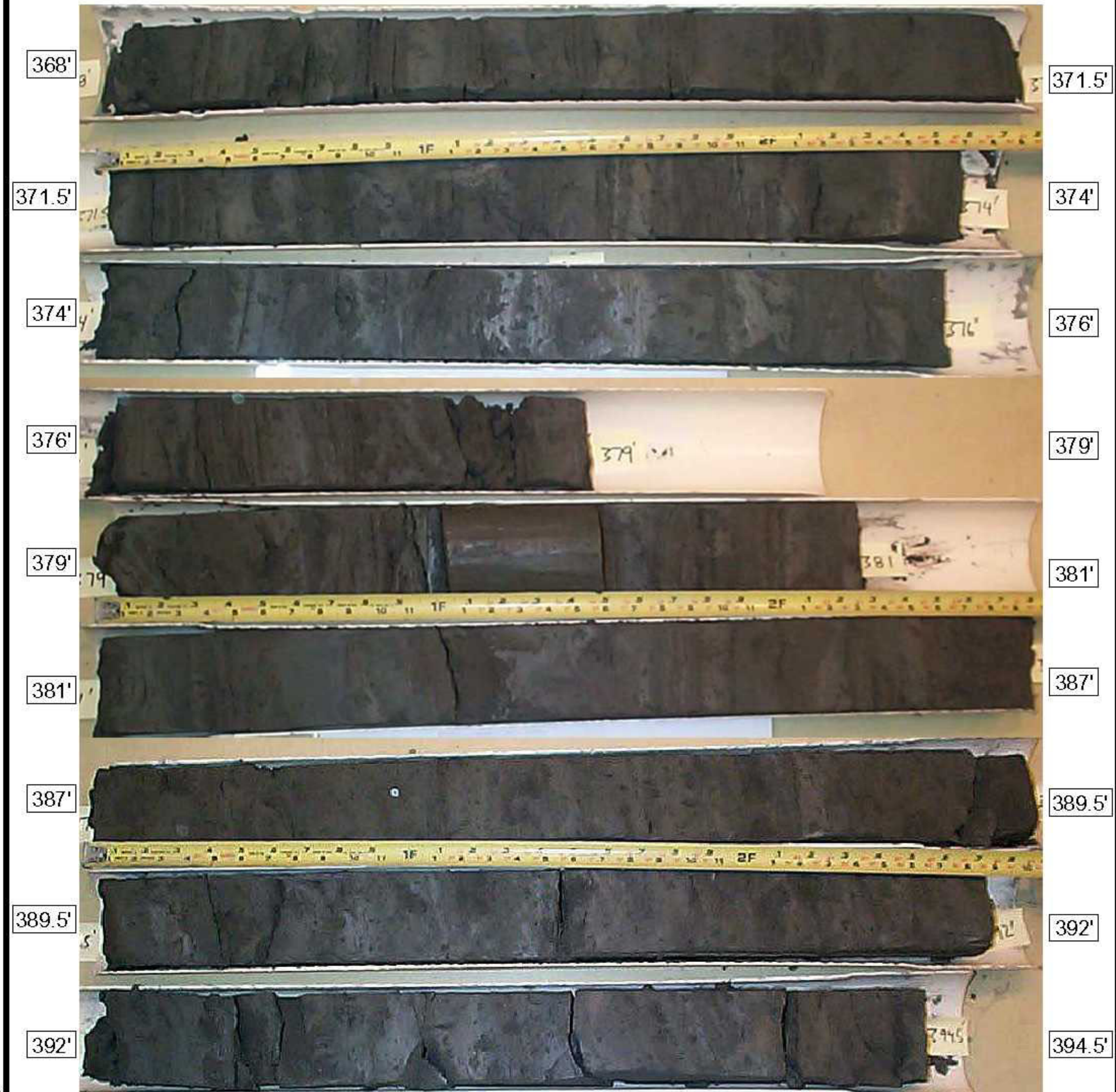
FIG. C-4
Sheet 15 of 20

File: I:\Drafting\211\09869-002\21-1-09869-002 Soil Core.dwg Date: 07-16-2003 Author: SAC



NOTE

From 20 to 215 feet, 6-inch-diameter sonic core was recovered. From 215 to 501 feet, 4-inch-diameter wireline core was recovered.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

SOIL CORE PHOTOGRAPHS
BORING PB-12
368 TO 394.5 FEET

July 2003 | 21-1-09869-002

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FIG. C-4
Sheet 16 of 20

File: I:\Drafting\211\09869-002\21-1-09869-002 Soil Core.dwg Date: 07-16-2003 Author: SAC

NOTE

From 20 to 215 feet, 6-inch-diameter sonic core was recovered. From 215 to 501 feet, 4-inch-diameter wireline core was recovered.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

SOIL CORE PHOTOGRAPHS
BORING PB-12
394.5 TO 417 FEET

July 2003 21-1-09869-002

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FIG. C-4
Sheet 17 of 20

File: I:\Drafting\211\09869-002\21-1-09869-002 Soil Core.dwg Date: 07-16-2003 Author: SAC

NOTE
From 20 to 215 feet, 6-inch-diameter sonic core was recovered. From 215 to 501 feet, 4-inch-diameter wireline core was recovered.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

SOIL CORE PHOTOGRAPHS
BORING PB-12
417 TO 436.5 FEET

July 2003 | 21-1-09869-002

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FIG. C-4
Sheet 18 of 20

File: I:\Drafting\211\09869-002\21-1-09869-002 Soil Core.dwg Date: 07-16-2003 Author: SAC

NOTE
From 20 to 215 feet, 6-inch-diameter sonic core was recovered. From 215 to 501 feet, 4-inch-diameter wireline core was recovered.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

SOIL CORE PHOTOGRAPHS
BORING PB-12
436.5 TO 489.5 FEET

July 2003 | 21-1-09869-002

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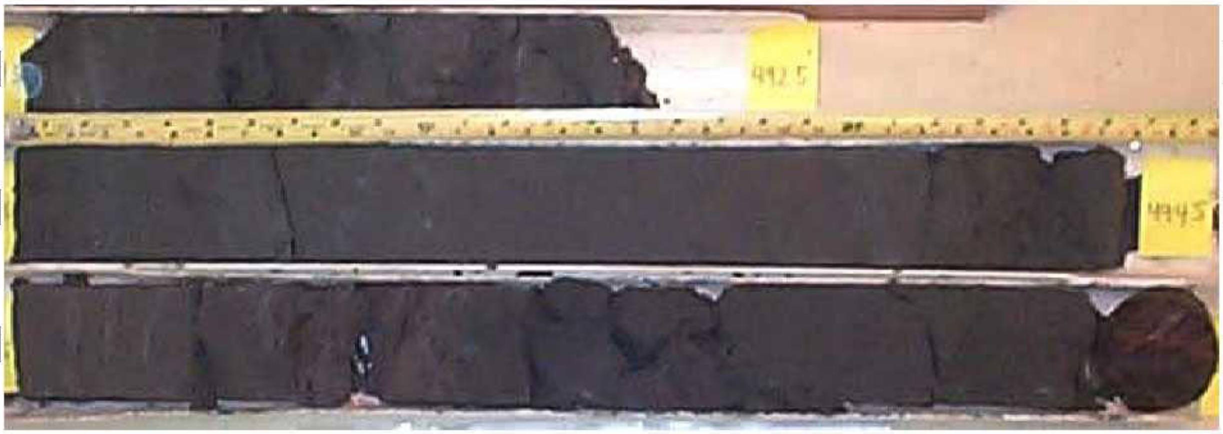
FIG. C-4
Sheet 19 of 20

File: I:\Drafting\211\09869-002\21-1-09869-002 Soil Core.dwg Date: 07-16-2003 Author: SAC

489.5' 492.5'

492.5' 494.5'

494.5' 501'



End of Wireline Core

NOTE

From 20 to 215 feet, 6-inch-diameter sonic core was recovered. From 215 to 501 feet, 4-inch-diameter wireline core was recovered.

Brightwater Treatment Plant
Route 9 Site
Woodinville, Washington

SOIL CORE PHOTOGRAPHS
BORING PB-12
489.5 TO 501 FEET

July 2003 21-1-09869-002

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FIG. C-4
Sheet 20 of 20

File: I:\Drafting\2111\09869-002\21-1-09869-002 Soil Core.dwg Date: 07-16-2003 Author: SAC

ATTACHMENT D

PROPOSED IPS GEOTECHNICAL LABORATORY TESTING PROCEDURES AND RESULTS AND RADIOCARBON DATING RESULTS

Attachment D
Proposed IPS Geotechnical Laboratory Testing Procedures and Results and Radiocarbon Dating Results

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Figure D-14 Hydraulic Conductivity Test, PB-12, S-64 (2 sheets)
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Beta Analytic Inc. May 15, 2003, letter regarding "Radiocarbon Dating Results for Samples 21109869001-128, 21109869001-197" (7 sheets)

INTRODUCTION

This attachment contains descriptions of the procedures and the results of the geotechnical laboratory tests performed on soil samples retrieved from the IPS boring (boring PB-12). The laboratory testing program included a variety of tests to classify the soils into similar geologic groups, to characterize each geologic unit, and to provide data for the interpretive report (by others). The laboratory testing was performed by an engineer or an experienced technician at the Shannon & Wilson, Inc. laboratory in Seattle.

Classification and index laboratory tests included visual classification and tests to determine natural water content, unit weight, grain-size distribution, percent passing No. 200 sieve, Atterberg limits, and hydraulic conductivity. The following sections describe the laboratory testing procedures.

VISUAL CLASSIFICATION

All of the soil samples recovered from the borings were visually classified in our warehouse using a system based on American Society for Testing of Materials (ASTM) Designation: D-2487, Standard Test Method for Classification of Soil for Engineering Purposes, and ASTM Designation: D-2488, Standard Recommended Practice for Description of Soils (Visual-Manual Procedure). This visual classification method allows for convenient and consistent comparison of soils from widespread geographic areas. Using this method, the soils can be classified by using the Unified Soil Classification System (USCS). The individual sample classifications have been incorporated into the boring logs presented in Attachment C. The USCS codes are also shown on laboratory results, Figures D-1 through D-16.

WATER CONTENT DETERMINATION

The natural water content of representative soil samples recovered from the sonic and wireline core were determined in general accordance with ASTM Designation: D-2216, Standard Method of Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures. Comparison of natural water content of a soil with its index properties can be useful in characterizing soil unit weight, consistency, compressibility, and strength. The water contents are plotted on the boring log presented in Attachment C.

UNIT WEIGHT DETERMINATION

The unit weights of several relatively undisturbed core samples were determined in the laboratory. The dimensions of each sample were measured, the sample was weighed, and the moist unit weight was calculated. A separate representative sample was taken to determine the water content and the dry unit weight was calculated. The determination was performed in general accordance with ASTM D 2937-94, Test Method for Density of Soil in Place by the Drive-Cylinder Method. Unit weights are presented in the table below.

Table D-1. Summary of Unit Weight Determinations

Boring	Sample	Depth	Description	Wet Unit Weight, pcf	Dry Unit Weight, pcf	Moisture Content, percent
PB-12	S-22	85.9	Dark gray, gravelly, silty SAND; pockets of clayey silt to sity clay; SM	144.6	130.9	10.6
PB-12	S-23	88.6	Gray, clayey SILT; ML	129.5	107.4	20.6
PB-12	S-64	203.2	Gray, fine sandy, clayey SILT; ML	129.5	106.7	21.3
PB-12	S-72	216.1	Gray, clayey SILT, trace of fine sand; interbedded with fine sandy silt and silty fine sand; ML	129.5	104.9	23.4
PB-12	S-89	285.3	Gray, fine sandy, silty CLAY; CL	133.9	112.1	19.5
PB-12	S-102	331.7	Dark gray, fine sandy, clayey SILT; ML	129.1	104.8	23.2

pcf = pounds per cubic foot

GRAIN-SIZE ANALYSIS

Grain-size analyses were performed on selected samples of granular soil in general accordance with ASTM Designation: D-422, Standard Method for Particle-Size Analysis of Soils. The general procedures used to determine the grain-size distribution of the soil samples included sieve and combined sieve and hydrometer analyses. Grain size distribution is used to assist in classifying soils and to provide correlation with soil properties, including permeability and capillarity.

Results of the grain size analyses are plotted on the grain-size distribution curves presented in Figures D-1 through D-5. Each gradation sheet provides the USCS group symbol, the sample description, water content, and the Atterberg Limits (if performed).

PERCENT PASSING NO. 200 SIEVE

Percent passing the No. 200 sieve tests were performed on selected samples in general accordance with ASTM Designation: D-1140, Standard Method for Amount of Material in Soils Finer than the No. 200 (75 µm) Sieve. Results of these analyses are presented in Figures D-1 through D-5. Along with each plot is a tabular summary containing the sample description, including the USCS symbol for the soil group, percentage of fines passing the No. 200 sieve, and the natural water content.

The percent of fines is used to assist in classifying soils and to provide correlation with soil properties including permeability, capillary action, susceptibility to liquefaction, and ability to treat the soil using certain ground modification techniques.

ATTERBERG LIMITS DETERMINATION

Soil plasticity was determined by performing Atterberg Limits tests on selected fine-grained samples. The tests were conducted in general accordance with ASTM Designation: D-4318, Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils. The Atterberg limits include Liquid Limit (LL), Plastic Limit (PL), and Plasticity Index (PI=LL-PL). They are generally used to assist in classification of soils, indicate soil consistency (when compared with natural water content), and provide correlation to soil properties including compressibility and strength. The results are shown on the boring log in Attachment C and plotted on the plasticity charts presented in Figures D-6 through D-8. The plasticity charts provide USCS group symbol, the sample description, water content, and percent passing the No. 200 sieve (if a grain size analysis was performed).

HYDRAULIC CONDUCTIVITY TESTS

Hydraulic conductivity tests were performed on selected samples in general accordance with ASTM Designation D-2434, Standard Test Method for Permeability of Granular Soils (Constant Head), and ASTM Designation D-5084, Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter. Bulk samples were compacted to a specific density and moisture content that we estimate are representative of in-place conditions. Relatively undisturbed samples were trimmed to a specific height-to-diameter ratio, measured and weighed to estimate the in-place conditions. Relatively undisturbed samples were trimmed vertically or horizontally to determine vertical or horizontal hydraulic conductivity respectively. Seven vertical and one horizontal hydraulic conductivity tests were completed.

In general, test method D-2434 was used to test compacted soil samples containing less than 10% soil finer than the No. 200 sieve (75-µm) using a rigid wall permeameter. Hydraulic conductivity values were determined by maintaining a constant hydraulic head difference across the test specimen and measuring the rate of water passing through it. Each test specimen was tested until turbulent flow was observed.

Flexible wall hydraulic conductivity tests were performed on soil samples containing more than 10% soil finer than the No. 200 sieve (75-µm). Permeation of the test specimens was accomplished with tap water using Method C, Falling-Head Test with Increasing Tailwater Level.

Test results are presented on Figures D-9 through D-16. A summary of the test results is presented in the table below.

RADIOCARBON DATING TESTS

Two samples containing some organics were submitted to Beta Analytic Inc. of Miami, Florida for radiocarbon dating. These tests were performed to better clarify the geologic interpretation at the site. The Beta Analytic Inc. test results are included in this attachment following the geotechnical laboratory testing.

Table D-2. Summary of Hydraulic Conductivity Test Results

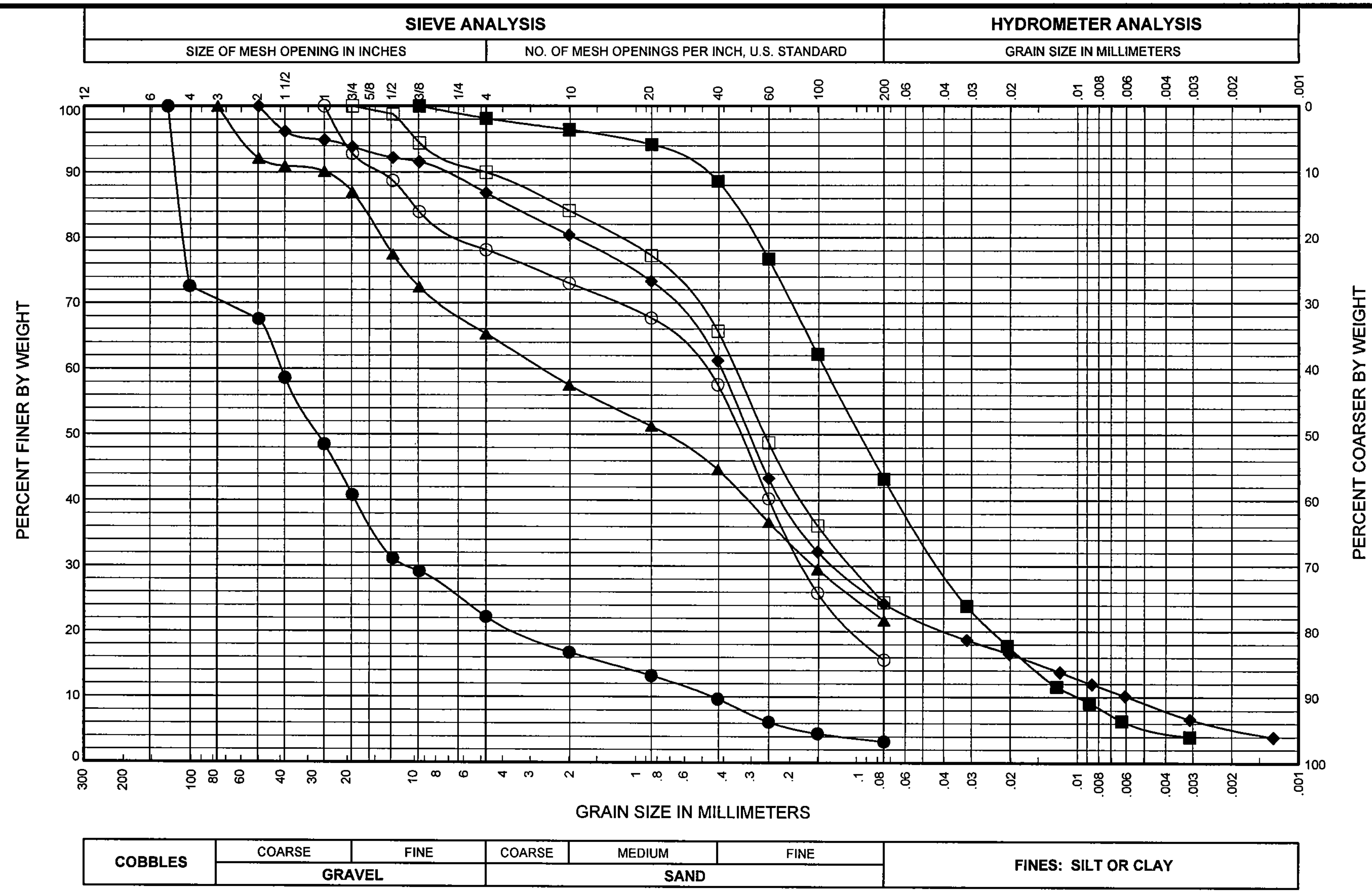
Boring	Sample	Depth	Description	Test Method	Sample Type	Wet Unit Weight, pcf	Moisture Content, percent	Measured Hydraulic Conductivity, cm/s
PB-12	S-8	41.0	Gray, silty, gravelly SAND; SM	D-5084	Compacted	137.2	6.1	5.1×10^{-4}
PB-12	S-21	84.0	Gray, silty, gravelly SAND; SM	D-5084	Compacted	147.7	13.4	3.9×10^{-5}
PB-12	S-26	96.0	Gray, silty, fine SAND; SM	D-5084	Compacted	127.6	21.2	4.1×10^{-5}
PB-12	S-40	131.0	Dark gray, slightly silty, gravelly SAND; SM	D-2434	Compacted	122.0	9.6	1.4×10^{-2}
PB-12	S-51	160.0	Gray, gravelly, silty SAND; SM	D-5084	Compacted	132.1	10.5	6.9×10^{-4}
PB-12	S-64	203.2	Gray, fine sandy, clayey SILT; ML	D-5084	Undisturbed	129.5	21.3	1.5×10^{-5}
PB-12	S-89	285.3	Gray, fine sandy, silty CLAY; CL	D-5084	Undisturbed	133.9	19.5	4.1×10^{-6}
PB-12	S-102	331.7	Dark gray, fine sandy, clayey SILT; ML	D-5084	Undisturbed	129.1	23.2	1.3×10^{-6} (horizontal)

NOTES:

1. Vertical hydraulic conductivity was measured for samples S-8, S-21, S-26, S-40, S-51, S-64, and S-89. Horizontal hydraulic conductivity was measured for sample S-102.
2. pcf = pounds per cubic foot
3. cm/s = centimeters per second

REFERENCE

American Society for Testing and Materials (ASTM), 2003, 2003 Annual book of standards, Construction, v. 04.08, Soil and rock (I): D 420 – D 5779: West Conshohocken, Pa.



BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● PB-12, R-1	21.0	GP	Brown, sandy, cobbly GRAVEL, trace of silt	3.2	6.9			
■ PB-12, R-2	30.0	SM	Gray, silty, fine to medium SAND, trace of gravel	43.3	11.9			
▲ PB-12, R-4	41.0	SM	Gray, silty, gravelly SAND	21.7	6.1			
◆ PB-12, R-5	51.0	SM	Gray, gravelly, silty SAND	24.2	8.8			
○ PB-12, R-6	61.0	SM	Gray, silty, gravelly SAND	15.6	10.4			
□ PB-12, R-7	70.0	SM	Gray, slightly gravelly, silty SAND	24.4	10.9			

Brightwater Treatment Plant
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GRAIN SIZE DISTRIBUTION BORING PB-12, R-1 TO R-7

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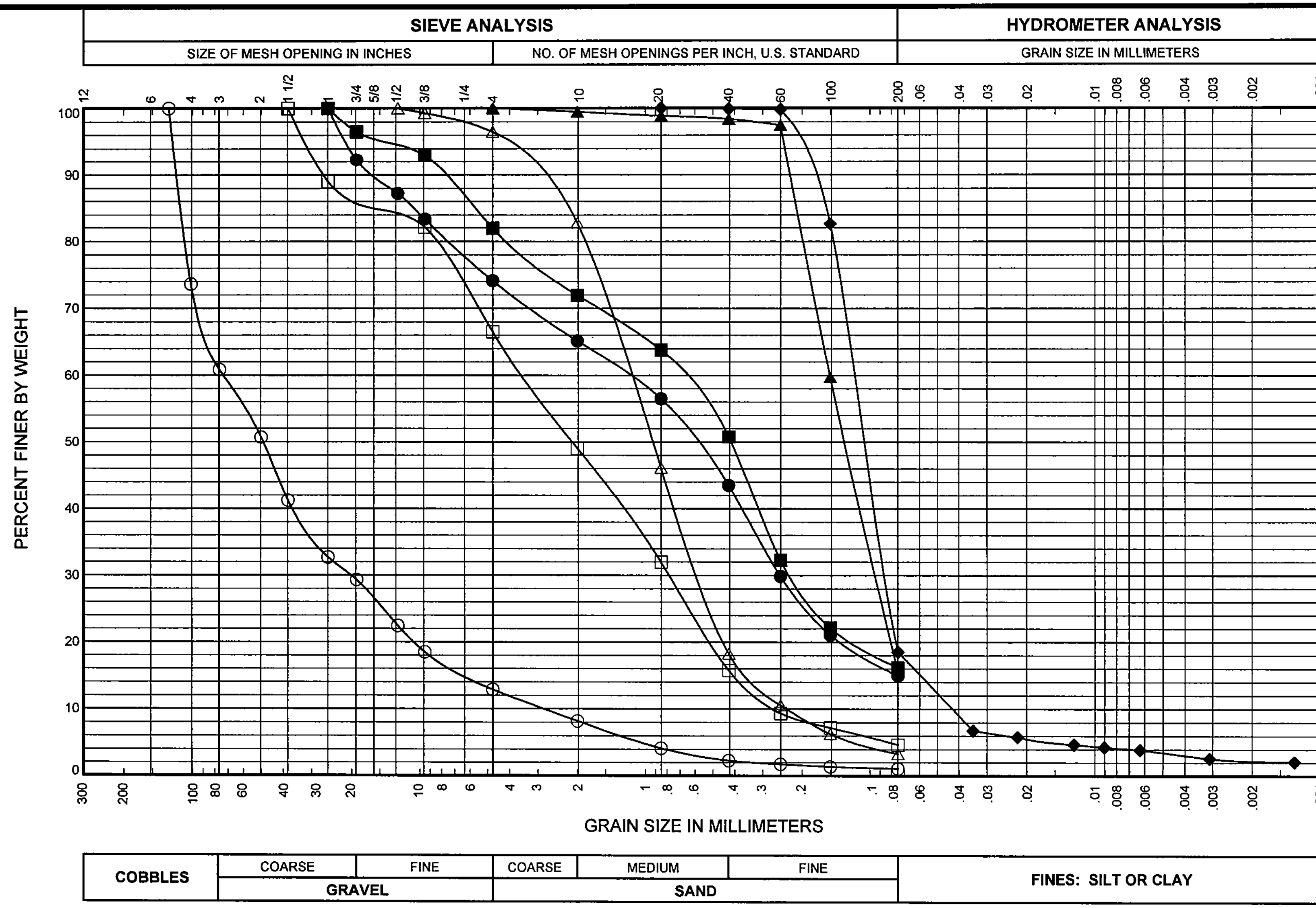
FIG. D-1



GSAMAIN1 21-09869.GPJ SHAN_WIL.GDT 7/16/03

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● PB-12, R-8	75.0	SM	Gray, silty, gravelly SAND	14.9	9.1			
■ PB-12, R-8	84.0	SM	Gray, silty, gravelly SAND	16.2	12.6			
▲ PB-12, R-10	95.0	SM	Gray, silty, fine SAND	15.5	22.3			
◆ PB-12, R-10	96.0	SM	Gray, silty, fine SAND	18.5	21.2			
○ PB-12, R-12	110.0	GW	Gray, slightly sandy, cobbly GRAVEL, trace of silt	1.1	4.2			
□ PB-12, R-12	115.8	SP	Gray, gravelly SAND, trace of silt	4.7	7.1			
△ PB-12, R-12	124.0	SP	Gray SAND, trace of gravel and silt	3.3	11.3			

Brightwater Treatment Plant
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GRAIN SIZE DISTRIBUTION
BORING PB-12, R-8 TO R-12

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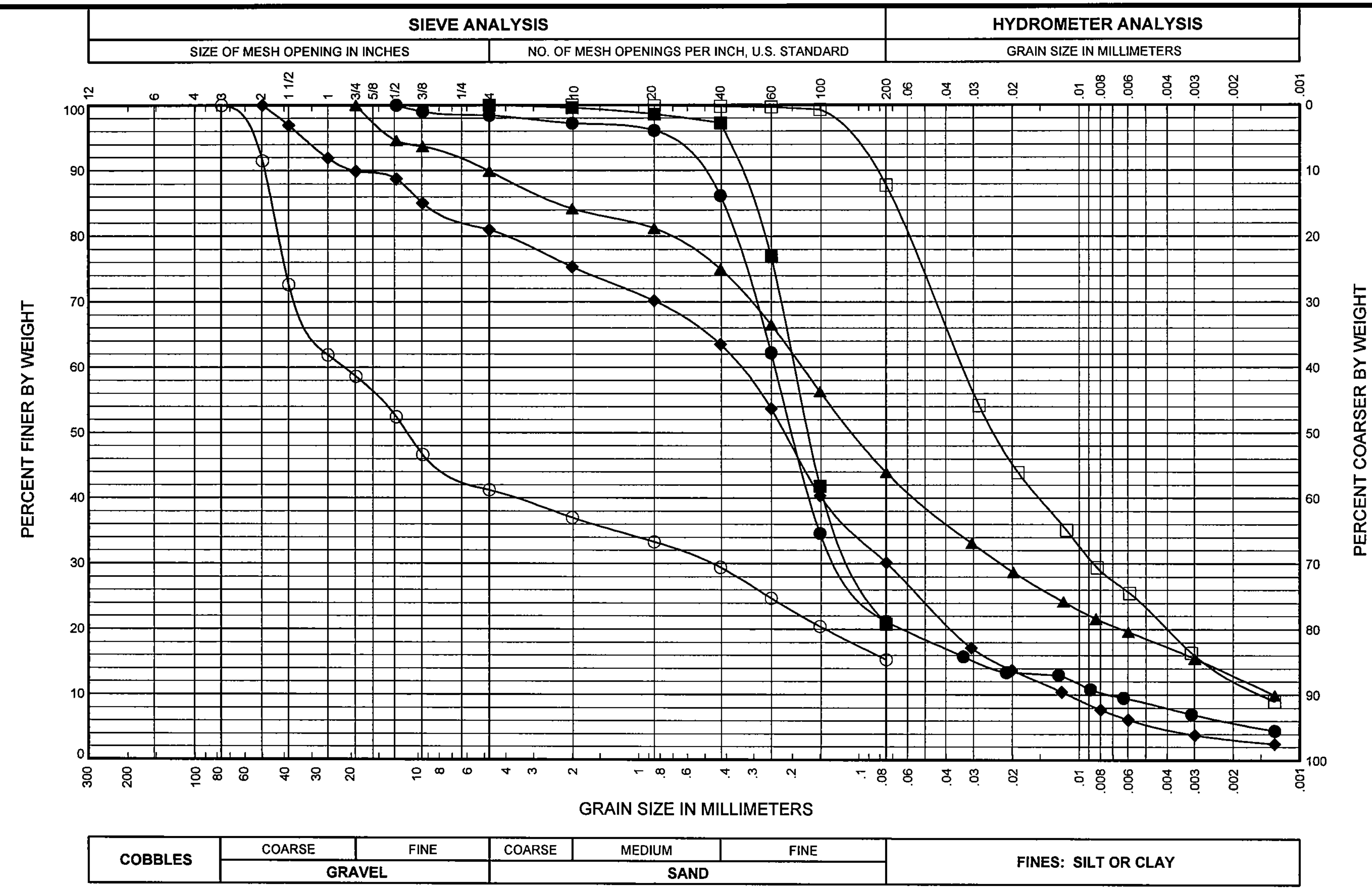
FIG. D-2

FIG. D-2



BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● PB-12, R-14	140.0	SM	Gray, silty, fine to medium SAND, trace of gravel	21.2	15.0			
■ PB-12, R-15	149.5	SM	Gray, silty, fine SAND	20.8	16.3			
▲ PB-12, R-16	159.4	SM	Gray, slightly clayey, slightly gravelly, silty SAND	43.9	13.7			
◆ PB-12, R-17	160.0	SM	Gray, gravelly, silty SAND	30.1	10.5			
○ PB-12, R-19	178.0	GM	Gray-brown, silty, sandy, GRAVEL	15.3	7.9			
□ PB-12, R-20	198.0	ML	Gray, fine sandy, clayey SILT	87.8	20.1			

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GRAIN SIZE DISTRIBUTION BORING PB-12, R-14 TO R-20

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FIG. D-3

FIG. D-3

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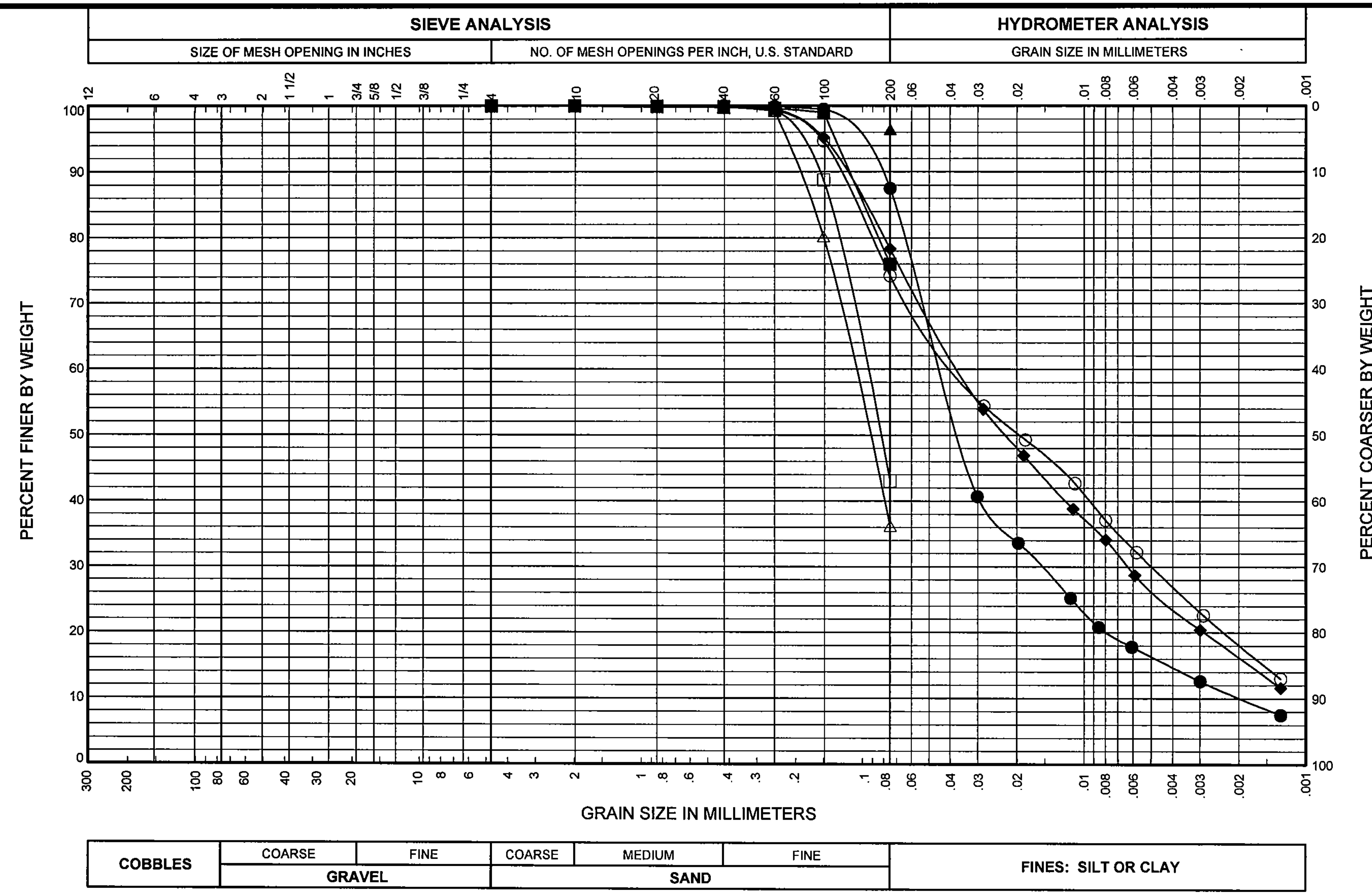

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● PB-12, R-21	203.2	ML	Gray, fine sandy, clayey SILT	87.5	24.5	25	22	4
■ PB-12, R-22	211.9	ML	Dark gray, fine sandy SILT	76.0	25.3			
▲ PB-12, R-23	216.1	ML	Gray, clayey SILT, trace of fine sand	96.4	23.4	28	23	6
◆ PB-12, R-29	257.8	ML	Gray, fine sandy, clayey SILT	78.3	21.8			
○ PB-12, R-38	285.3	CL	Gray, fine sandy, silty CLAY	74.2	24.1	26	16	10
□ PB-12, R-39	290.5	SM	Dark gray, silty, fine SAND	43.1	24.1			
△ PB-12, R-45	315.6	SM	Dark gray, silty, fine SAND	36.2	23.9			

Brightwater Treatment Plant
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GRAIN SIZE DISTRIBUTION
BORING PB-12, R-21 TO R-45

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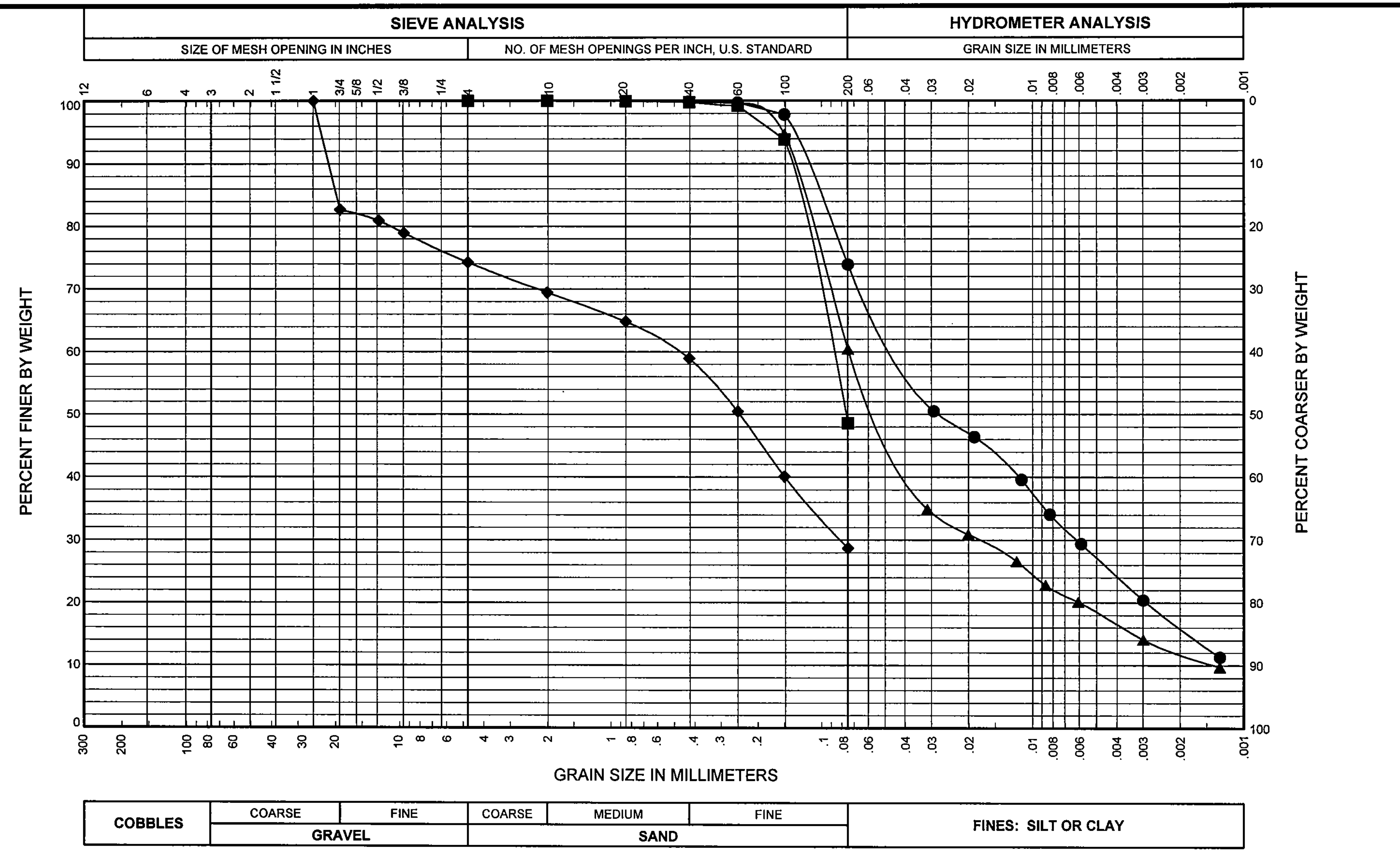
FIG. D-4

FIG. D-4



BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● PB-12, R-48	331.7	ML	Dark gray, fine sandy, clayey SILT	73.9	24.5			
■ PB-12, R-50	343.8	SM	Dark gray, silty, fine SAND	48.6	25.5			
▲ PB-12, R-51	355.7	ML	Dark gray, fine sandy, clayey SILT	60.4	22.7			
◆ PB-12, R-62	445.6	SM	Gray, gravelly, silty SAND, trace of clay	28.7	8.6			

Brightwater Treatment Plant
Route 9 Site
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GRAIN SIZE DISTRIBUTION BORING PB-12, R-48 TO R-62

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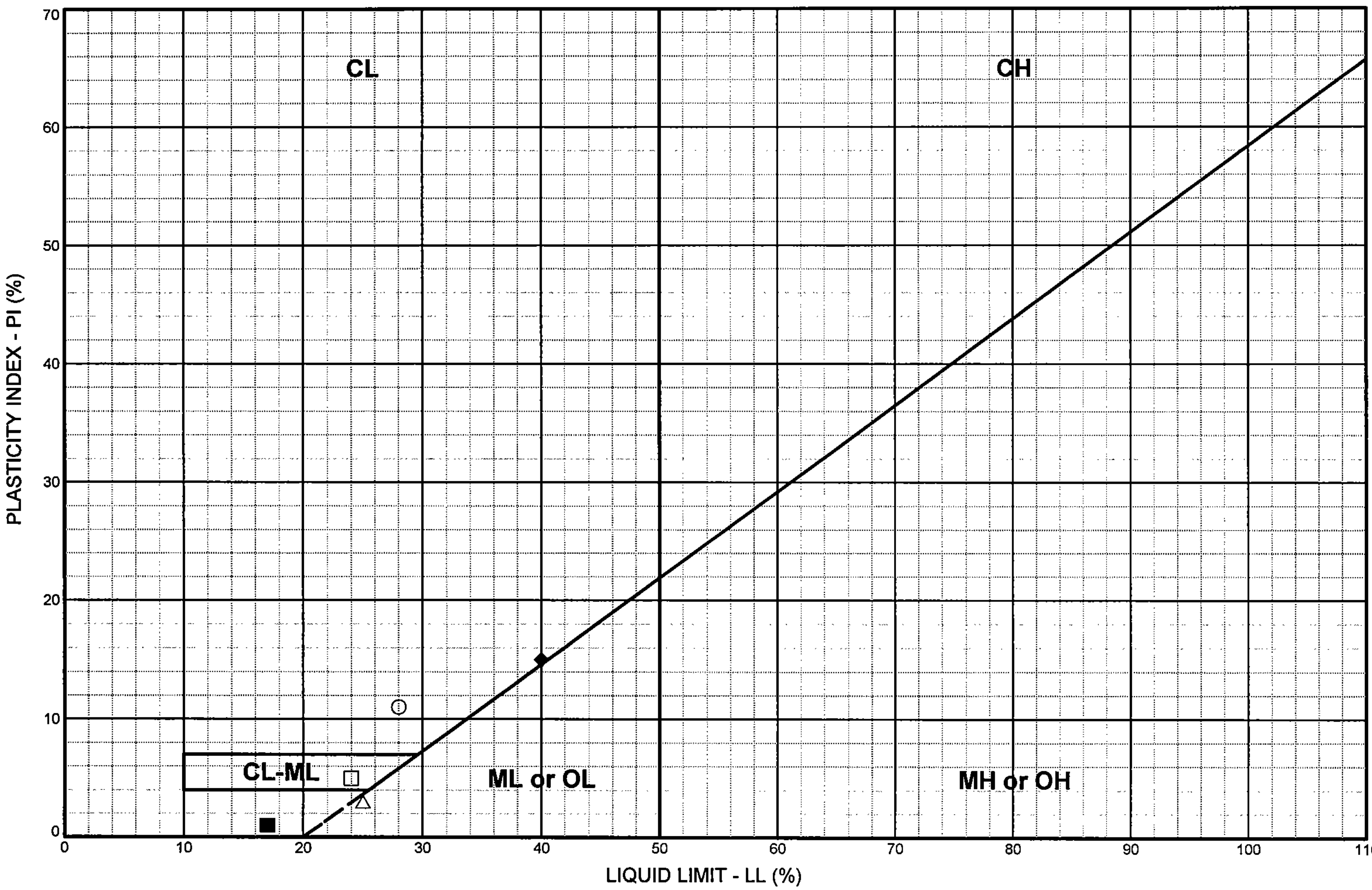
FIG. D-5



LEGEND

CL: Low plasticity inorganic clays; sandy and silty clays

CH: High plasticity inorganic clays

ML or OL: Inorganic and organic silts and clayey silts of low plasticity

MH or OH: Inorganic and organic silts and clayey silts of high plasticity

CL-ML: Silty clays and clayey silts

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
PB-12, R-1	23.0	ML	Brown, fine sandy SILT, trace of clay	NP	NP	NP	18.2	
■ PB-12, R-8	80.0	SM	Gray, clayey, silty SAND	17	16	1	10.2	
PB-12, R-9	85.9	SM	Dark gray, gravelly, silty SAND, trace of clay	NP	NP	NP	10.6	
◆ PB-12, R-10	102.0	CL	Gray, silty CLAY	40	25	15	28.9	
○ PB-12, R-16	156.5	CL	Gray, slightly sandy, silty CLAY	28	17	11	16.7	
□ PB-12, R-20	195.7	CL-ML	Gray, sandy, silty CLAY	24	19	5	18.1	
△ PB-12, R-21	203.2	ML	Gray, fine sandy, clayey SILT	25	22	3	24.5	87.5

Brightwater Treatment Plant
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PLASTICITY CHART
BORING PB-12, R-1 TO R-21

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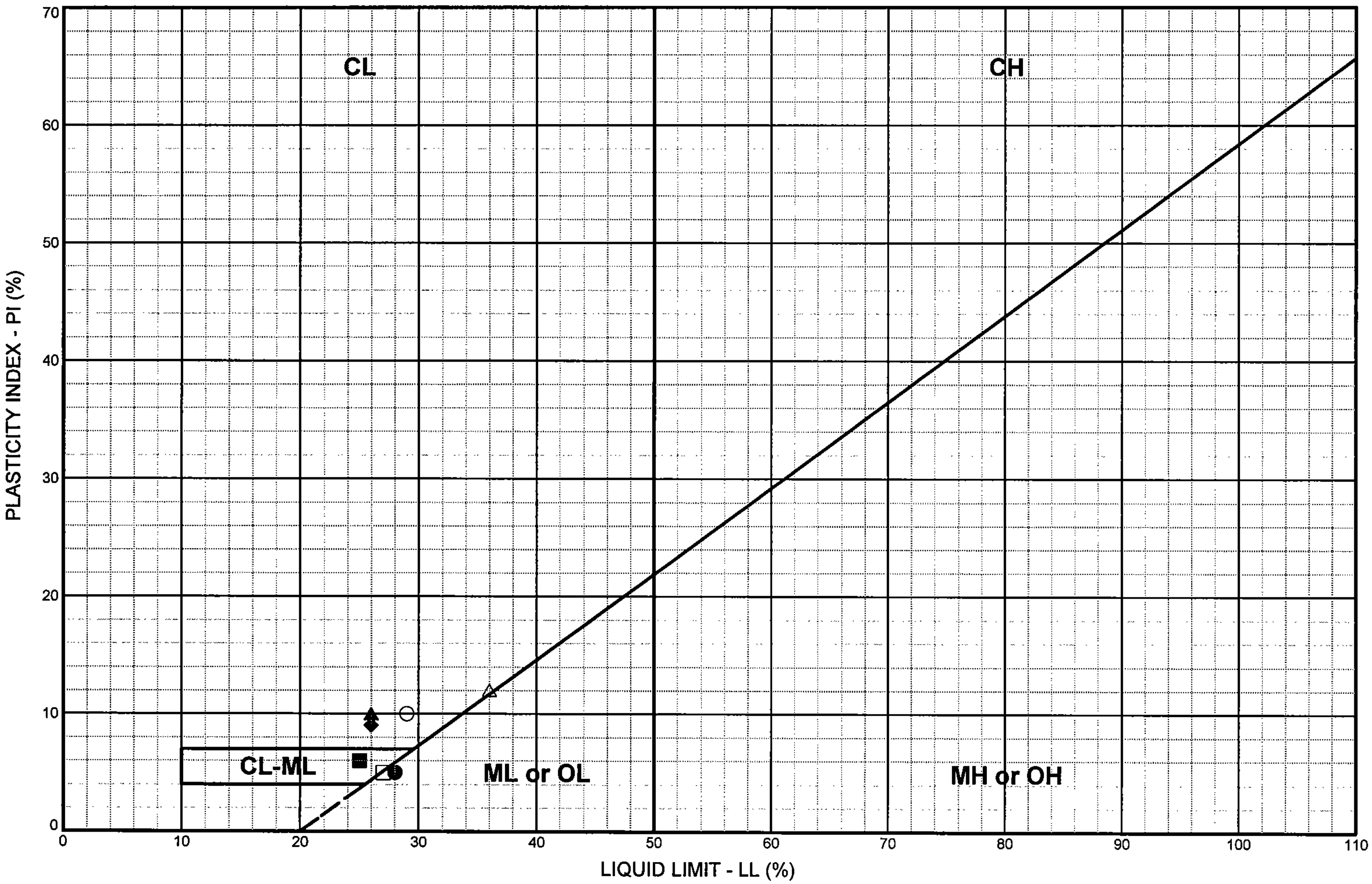
FIG. D-6

ATTMAIN1 21-09869.GPJ SHAN_WIL.GDT 7/16/03

FIG. D-6



LEGEND

CL: Low plasticity inorganic clays; sandy and silty clays

CH: High plasticity inorganic clays

ML or OL: Inorganic and organic silts and clayey silts of low plasticity

MH or OH: Inorganic and organic silts and clayey silts of high plasticity

CL-ML: Silty clays and clayey silts

ATTMAIN1 21-09869.GPJ SHAN_WIL.GDT 7/16/03

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
● PB-12, R-23	216.1	ML	Gray, clayey SILT, trace of fine sand	28	23	5	23.4	96.4
■ PB-12, R-30	261.6	CL-ML	Gray, sandy, silty CLAY	25	19	6	21.3	
▲ PB-12, R-38	285.3	CL	Gray, fine sandy, silty CLAY	26	16	10	24.1	74.2
◆ PB-12, R-42	304.8	CL	Gray, silty CLAY, trace of fine sand	26	17	9	25.0	
○ PB-12, R-49	339.6	CL	Gray, silty CLAY, trace of fine sand	29	19	10	25.5	
□ PB-12, R-55	390.5	CL-ML	Gray, silty CLAY, trace of fine sand	27	22	5	21.1	
△ PB-12, R-59	429.0	CL	Gray, silty CLAY	36	24	12	30.5	

Brightwater Treatment Plant
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PLASTICITY CHART
BORING PB-12, R-23 TO R-59

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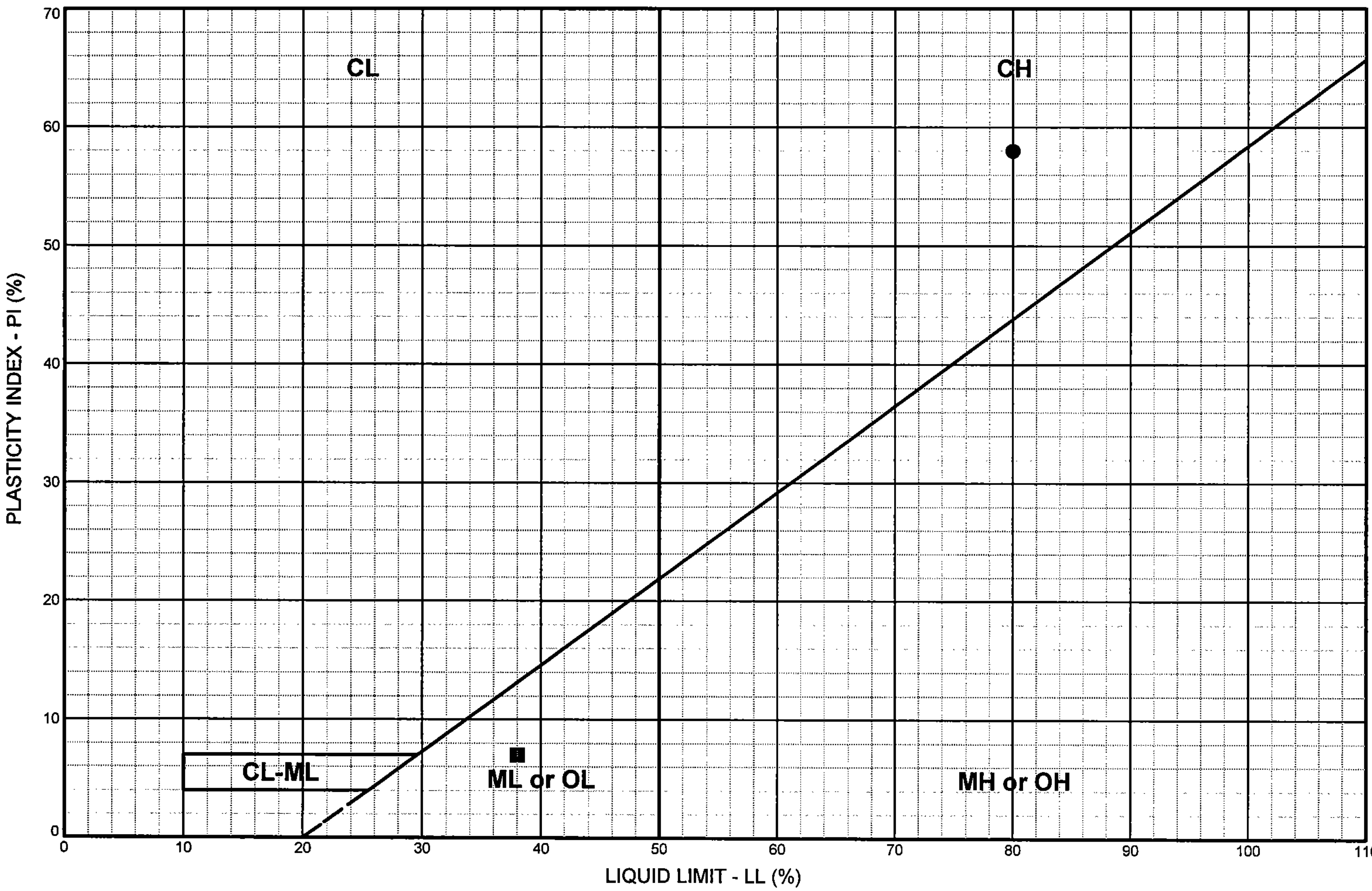
FIG. D-7

FIG. D-7



LEGEND

CL: Low plasticity inorganic clays; sandy and silty clays

CH: High plasticity inorganic clays

ML or OL: Inorganic and organic silts and clayey silts of low plasticity

MH or OH: Inorganic and organic silts and clayey silts of high plasticity

CL-ML: Silty clays and clayey silts

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
● PB-12, R-60	437.0	CH	Gray, silty CLAY	80	22	58	29.0	
■ PB-12, R-68	490.4	SM	Gray, clayey, silty SAND	38	31	7	28.9	

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PLASTICITY CHART
BORING PB-12, R-60 TO R-68

July 2003 21-1-09869-001

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FIG. D-8

FIG. D-8

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-90)

SHANNON & WILSON, INC.
Geotechnical & Environmental Consultants

Project	Brightwater	Job No.	21-1-09869-001			
Boring No.	PB-12	Tested by	RJT	On	4/15/2003	
Sample No.	S-8	Comp by	RJT	On	4/17/2003	
Depth (ft)	41	Checked by		On		

WATER CONTENT DATA:

	Before Test	After Test
Pan No.	X	KB
Wet+Tare	744.62	1043.25
Dry+Tare	707.89	969.21
Tare	103.09	364.50
WC, %	6.1	12.2

SPECIMEN DATA:

	Before Test	After Consol.	After Test
Height, m	0.0731	0.0730	0.0730
Diameter, m	0.0724	0.0724	0.0724
Wet Weight, g	661	689.95	689.95
Volume, ml	300.7	300.5	300.5
Area, m^2	0.00412	0.00412	0.00412
Wet Unit Wt, pcf	137.2	143.3	143.3
Dry Unit Wt, pcf	129.3	127.6	127.6
Est. Saturation,%	52.2	99.9	99.9

OTHER INFORMATION:

Burette Corr. Factor, BCF (vol. to height), 1ml = 0.0047 m
a = 2.13E-04 m^2
Specific Gravity ☑ Assumed ☐ Measured = 2.73
B-Coefficient = 0.97
Volume of Solid = 228.3 ml
Pore Volume (P.V.)= 72.4 ml
Begin Saturation
Begin Consolidation
Begin Permeation

Soil Classification: Gray, silty, gravelly SAND (SM)

FALLING-HEAD INCREASING TAILWATER LEVEL HYDRAULIC CONDUCTIVITY CALCULATION (METHOD C):

$$k=\frac{aL}{2At}\ln\left(\frac{h_1}{h_2}\right)$$

$$k_{20}=R_T k$$

a = cross-sectional area of standpipe, m^2
L = length of the sample, m
A = cross-sectional area of the sample, m^2
t = elapsed time between determination of h_1 and h_2, sec.

h_1 = head loss across the specimen at time t_1, m,
h_2 = head loss across the specimen at time t_2, m,
k_{20} = corrected hydraulic conductivity at temperature of 20 °C
R_T = correction factor for viscosity of water at various temperatures, T = (-0.02452*T+1.495)

MEASURED DATA:

Read Time			Elapsed Time	Temp T	Pressure Readings			Burette Readings						Head Loss h	Effective Stresses		Calculated Flow Volumes				Gradient (i)	k_{20}
day	hr	min	(hr)	(°C)	P_{cell} (psi)	P_{in} (psi)	P_{out} (psi)	V_{cell} (ml)	V_{in} (ml)	V_{out} (ml)	H_{cell} (m)	H_{in} (m)	H_{out} (m)	(m)	σ'_{max} (psi)	σ'_{min} (psi)	Inflow (ml)	Outflow (ml)	Storage (ml)	Cum. P.V.		(m/sec)
1		0	0	23.0	90.0	70.0	70.0	28.9	100.1	0.0	0.136	0.470	0.000	0.397	20.1	19.5				0	5.4	
1		1	0.02	23.0	90.0	70.0	70.0	28.9	95.3	5.2	0.136	0.448	0.024	0.350	20.1	19.6	4.8	5.2	-0.4	0.0690	4.8	3.7E-06
1		2	0.03	23.0	90.0	70.0	70.0	28.9	90.2	11.1	0.136	0.424	0.052	0.299	20.0	19.6	5.1	5.9	-0.8	0.1449	4.1	4.7E-06
1		3	0.05	23.0	90.0	70.0	70.0	28.9	85.7	15.9	0.136	0.403	0.075	0.255	20.0	19.6	4.5	4.8	-0.3	0.2091	3.5	4.6E-06
1		4	0.07	23.0	90.0	70.0	70.0	28.9	81.1	20.0	0.136	0.381	0.094	0.214	20.0	19.7	4.6	4.1	0.5	0.2692	2.9	5.1E-06
1		5	0.08	23.0	90.0	70.0	70.0	28.9	77.0	24.8	0.136	0.362	0.117	0.172	19.9	19.7	4.1	4.8	-0.7	0.3306	2.4	6.4E-06
1		6	0.10	23.0	90.0	70.0	70.0	28.9	74.0	26.9	0.136	0.348	0.126	0.148	19.9	19.7	3.0	2.1	0.9	0.3658	2.0	4.4E-06
																					Average for last 4:	5.1E-06

PB12S8.xls Data
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Figure D-9
Sheet 1 of 2

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-90)

SHANNON & WILSON, INC.
Geotechnical & Environmental Consultants

Project	Brightwater	Job No.	21-1-09869-001		
Boring No.	PB-12	Tested by	RJT	On	4/15/2003
Sample No.	S-8	Comp by	RJT	On	4/17/2003
Depth (ft)	41	Checked by		On	

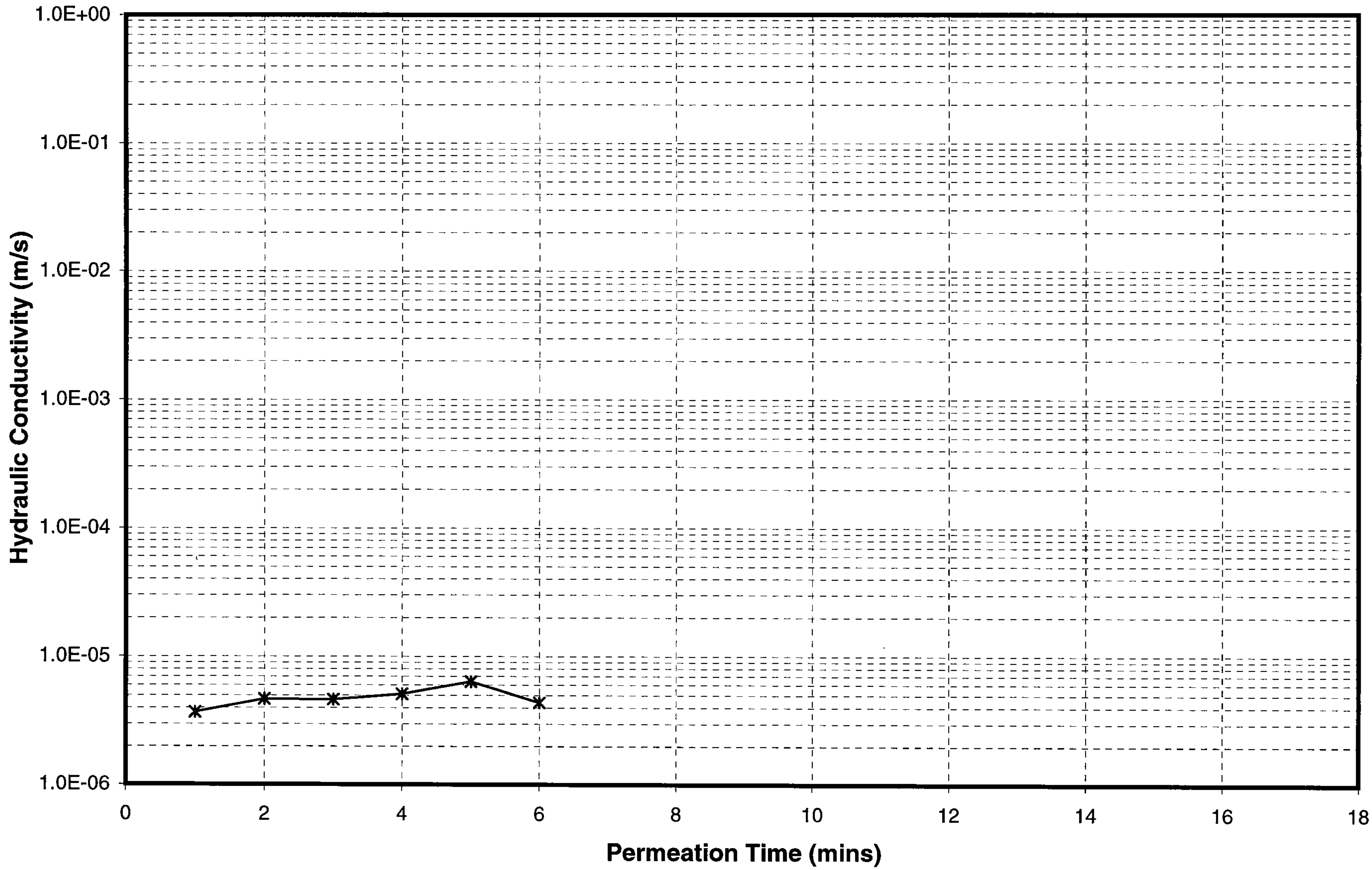

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Figure D-9
Sheet 2 of 2

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-90)

SHANNON & WILSON, INC.
Geotechnical & Environmental Consultants

Project	Brightwater	Job No.	21-1-09869-001		
Boring No.	PB-12	Tested by	RJT	On	4/15/2003
Sample No.	S-21	Comp by	RJT	On	4/16/2003
Depth (ft)	84	Checked by		On	

WATER CONTENT DATA:

	Before Test	After Test
Pan No.	X	E-8
Wet+Tare	471.17	709.35
Dry+Tare	428.47	646.47
Tare	110.55	99.61
WC, %	13.4	11.5

SPECIMEN DATA:

	Before Test	After Consol.	After Test
Height, m	0.0648	0.0651	0.0649
Diameter, m	0.0711	0.0711	0.0711
Wet Weight, g	609.17	609.74	609.74
Volume, ml	257.3	258.4	257.5
Area, m^2	0.00397	0.00397	0.00397
Wet Unit Wt, pcf	147.7	147.3	147.8
Dry Unit Wt, pcf	130.3	132.1	132.5
Est. Saturation,%	120.5	109.7	111.4

OTHER INFORMATION:

Burette Corr. Factor, BCF (vol. to height), 1ml = 0.0047 m

a = 2.13E-04 m^2

Specific Gravity ☑ Assumed ☐ Measured = 2.72

B-Coefficient = 1.00

Volume of Solid = 197.4 ml

Pore Volume (P.V.)= 59.8 ml

Begin Saturation

Begin Consolidation

Begin Permeation

Soil Classification: Gray, silty, gravelly SAND (SM)

FALLING-HEAD INCREASING TAILWATER LEVEL HYDRAULIC CONDUCTIVITY CALCULATION (METHOD C):

$$k=\frac{aL}{2At}\ln\left(\frac{h_1}{h_2}\right)$$

$$k_{20}=R_T k$$

a = cross-sectional area of standpipe, m^2

L = length of the sample, m

A = cross-sectional area of the sample, m^2

t = elapsed time between determination of h_1 and h_2, sec.

h_1 = head loss across the specimen at time t_1, m,

h_2 = head loss across the specimen at time t_2, m,

k_{20} = corrected hydraulic conductivity at temperature of 20 °C

R_T = correction factor for viscosity of water at various temperatures, T = (-0.02452*T+1.495)

MEASURED DATA:

Read Time			Elapsed Time	Temp	Pressure Readings			Burette Readings						Head Loss	Effective Stresses		Calculated Flow Volumes				Gradient	k_{20}
				T	P_{cell}	P_{in}	P_{out}	V_{cell}	V_{in}	V_{out}	H_{cell}	H_{in}	H_{out}	h	σ'_{max}	σ'_{min}	Inflow	Outflow	Storage	Cum.	(i)	
day	hr	min	(hr)	(°C)	(psi)	(psi)	(psi)	(ml)	(ml)	(ml)	(m)	(m)	(m)	(m)	(psi)	(psi)	(ml)	(ml)	(ml)	P.V.		(m/sec)
1		0	0	23.0	79.0	40.0	40.0	41.1	99.1	0.9	0.193	0.466	0.004	0.397	39.2	38.6				0	6.1	
1		2	0.03	23.0	79.0	40.0	40.0	41.1	98.0	2.0	0.193	0.461	0.009	0.386	39.2	38.6	1.1	1.1	0.0	0.0184	6.0	3.6E-07
1		4	0.07	23.0	79.0	40.0	40.0	41.1	96.9	3.1	0.193	0.455	0.015	0.376	39.2	38.6	1.1	1.1	0.0	0.0368	5.8	3.7E-07
1		9	0.15	23.0	79.0	40.0	40.0	41.1	93.5	6.5	0.193	0.439	0.031	0.344	39.1	38.7	3.4	3.4	0.0	0.0936	5.3	4.8E-07
1		13	0.22	23.0	79.0	40.0	40.0	41.1	92.2	7.8	0.193	0.433	0.037	0.332	39.1	38.7	1.3	1.3	0.0	0.1153	5.1	2.4E-07
1		15	0.25	23.0	79.0	40.0	40.0	41.1	91.1	8.8	0.193	0.428	0.041	0.322	39.1	38.7	1.1	1.0	0.1	0.1329	5.0	4.1E-07
1		17	0.28	23.0	79.0	40.0	40.0	41.1	90.3	9.6	0.193	0.424	0.045	0.314	39.1	38.7	0.8	0.8	0.0	0.1462	4.9	3.2E-07
1		19	0.32	23.0	79.0	40.0	40.0	41.1	89.8	10.1	0.193	0.422	0.047	0.310	39.1	38.7	0.5	0.5	0.0	0.1546	4.8	2.0E-07
1		21	0.35	23.0	79.0	40.0	40.0	41.1	88.8	11.0	0.193	0.417	0.052	0.301	39.1	38.7	1.0	0.9	0.1	0.1705	4.6	3.9E-07
1		23	0.38	23.0	79.0	40.0	40.0	41.1	87.9	12.0	0.193	0.413	0.056	0.292	39.1	38.7	0.9	1.0	-0.1	0.1863	4.5	4.1E-07
1		25	0.42	23.0	79.0	40.0	40.0	41.1	87.0	12.9	0.193	0.409	0.061	0.283	39.1	38.7	0.9	0.9	0.0	0.2014	4.4	4.0E-07
1		27	0.45	23.0	79.0	40.0	40.0	41.1	86.2	13.7	0.193	0.405	0.064	0.276	39.1	38.7	0.8	0.8	0.0	0.2147	4.3	3.6E-07
																					Average for last 4:	3.9E-07

PB12S21.xls Data
5/20/2003 10:36 AM

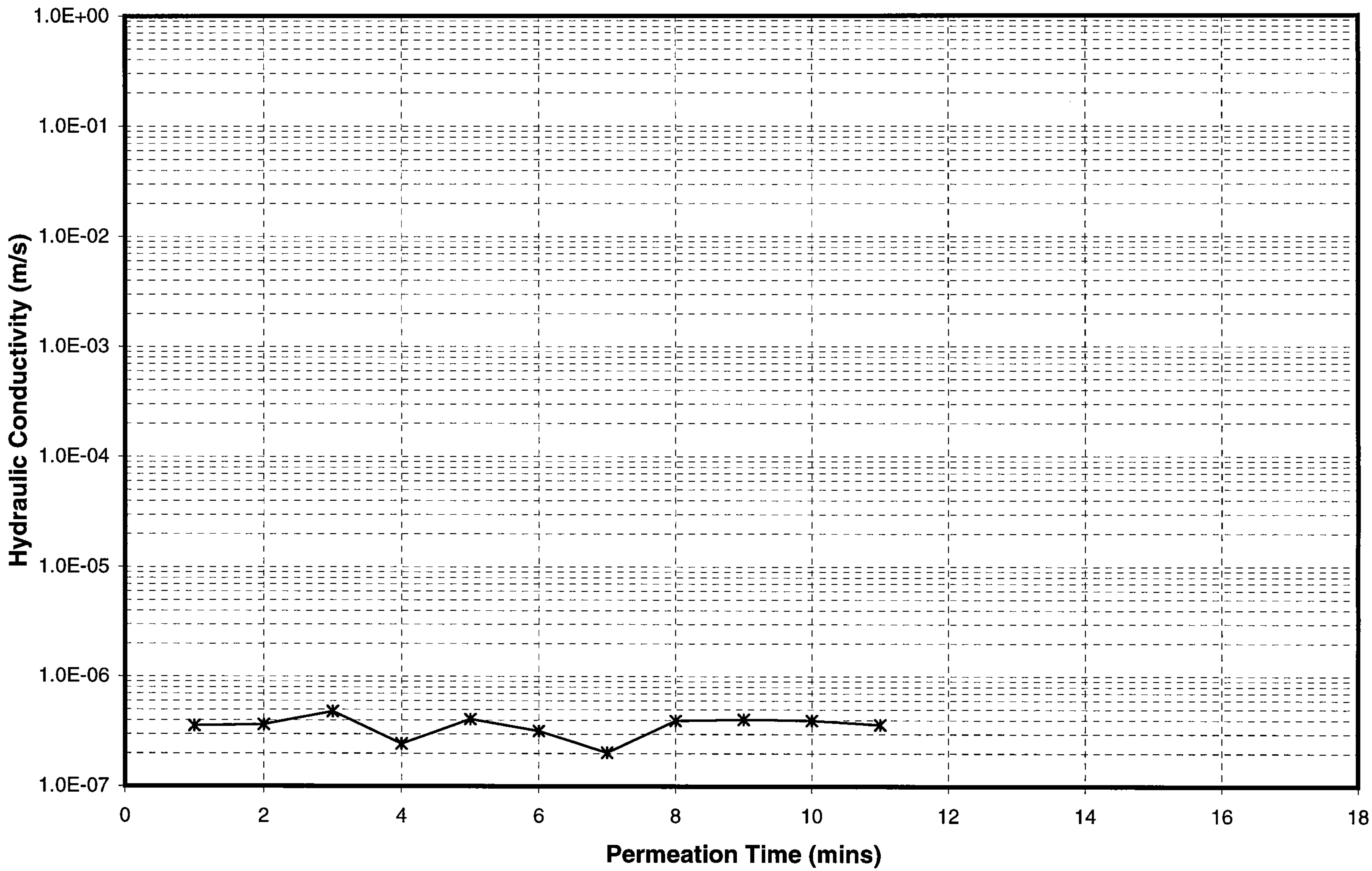
Figure D-10

Sheet 1 of 2

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-90)

SHANNON & WILSON, INC.
Geotechnical & Environmental Consultants

Project	Brightwater	Job No.	21-1-09869-001		
Boring No.	PB-12	Tested by	RJT	On	4/15/2003
Sample No.	S-21	Comp by	RJT	On	4/16/2003
Depth (ft)	84	Checked by		On	



PB12S21.xls Chart
5/20/2003 10:44 AM

Figure D-10
Sheet 2 of 2

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-90)

SHANNON & WILSON, INC.
Geotechnical & Environmental Consultants

Project	Brightwater	Job No.	21-1-09869-001			
Boring No.	PB-12	Tested by	RJT	On	4/15/2003	
Sample No.	S-26	Comp by	RJT	On	4/16/2003	
Depth (ft)	96	Checked by		On		

WATER CONTENT DATA:

	Before Test	After Test
Pan No.	X	Z-17
Wet+Tare	484.77	798.67
Dry+Tare	417.08	680.92
Tare	98.52	161.96
WC, %	21.2	22.7

SPECIMEN DATA:

	Before Test	After Consol.	After Test
Height, m	0.0767	0.0768	0.0768
Diameter, m	0.0713	0.0713105	0.071311
Wet Weight, g	626.76	636.71	636.71
Volume, ml	306.4	306.8	306.6
Area, m^2	0.00399	0.00399	0.00399
Wet Unit Wt, pcf	127.6	129.5	129.6
Dry Unit Wt, pcf	105.3	105.5	105.6
Est. Saturation,%	94.4	101.5	101.6

OTHER INFORMATION:

Burette Corr. Factor, BCF (vol. to height), 1ml = 0.0047 m

a = 2.13E-04 m^2

Specific Gravity ☑ Assumed ☐ Measured = 2.72

B-Coefficient = 0.95

Volume of Solid = 190.0 ml

Pore Volume (P.V.)= 116.4 ml

Begin Saturation ______

Begin Consolidation ______

Begin Permeation ______

Soil Classification: Gray, silty fine SAND (SM)

FALLING-HEAD INCREASING TAILWATER LEVEL HYDRAULIC CONDUCTIVITY CALCULATION (METHOD C):

$$k = \frac{aL}{2At}\ln\left(\frac{h_1}{h_2}\right)$$

$$k_{20} = R_T k$$

a = cross-sectional area of standpipe, m^2
L = length of the sample, m
A = cross-sectional area of the sample, m^2
t = elapsed time between determination of h_1 and h_2, sec.

h_1 = head loss across the specimen at time t_1, m,
h_2 = head loss across the specimen at time t_2, m,
k_{20} = corrected hydraulic conductivity at temperature of 20 °C
R_T = correction factor for viscosity of water at various temperatures, T = (-0.02452*T+1.495)

MEASURED DATA:

Read Time			Elapsed Time	Temp T	Pressure Readings			Burette Readings						Head Loss h	Effective Stresses		Calculated Flow Volumes				Gradient (i)	k_{20}
					P_{cell}	P_{in}	P_{out}	V_{cell}	V_{in}	V_{out}	H_{cell}	H_{in}	H_{out}		σ'_{max}	σ'_{min}	Inflow	Outflow	Storage	Cum.		
day	hr	min	(hr)	(°C)	(psi)	(psi)	(psi)	(ml)	(ml)	(ml)	(m)	(m)	(m)	(m)	(psi)	(psi)	(ml)	(ml)	(ml)	P.V.		(m/sec)
1		0	0	23.0	104.0	60.0	60.0	79.6	99.8	3.5	0.374	0.469	0.016	0.376	44.4	43.9				0	4.9	
1		2	0.03	23.0	104.0	60.0	60.0	79.6	97.7	4.2	0.374	0.459	0.020	0.363	44.4	43.9	2.1	0.7	1.4	0.0120	4.7	5.7E-07
1		4.5	0.08	23.0	104.0	60.0	60.0	79.6	96.1	5.7	0.374	0.452	0.027	0.348	44.4	43.9	1.6	1.5	0.1	0.0253	4.5	5.2E-07
1		10	0.17	23.0	104.0	60.0	60.0	79.6	91.2	10.8	0.374	0.429	0.051	0.301	44.4	43.9	4.9	5.1	-0.2	0.0683	3.9	8.4E-07
1		13	0.22	23.0	104.0	60.0	60.0	79.6	90.0	11.9	0.374	0.423	0.056	0.290	44.3	43.9	1.2	1.1	0.1	0.0782	3.8	3.9E-07
1		17	0.28	23.0	104.0	60.0	60.0	79.6	88.5	13.5	0.374	0.416	0.063	0.276	44.3	43.9	1.5	1.6	-0.1	0.0915	3.6	4.1E-07
1		21	0.35	23.0	104.0	60.0	60.0	79.6	86.8	15.2	0.374	0.408	0.071	0.260	44.3	44.0	1.7	1.7	0.0	0.1061	3.4	4.7E-07
1		29	0.48	23.0	104.0	60.0	60.0	79.6	84.8	18.1	0.374	0.399	0.085	0.237	44.3	44.0	2.0	2.9	-0.9	0.1272	3.1	3.7E-07
																					Average for last 4:	4.1E-07

PB12S26.xls Data
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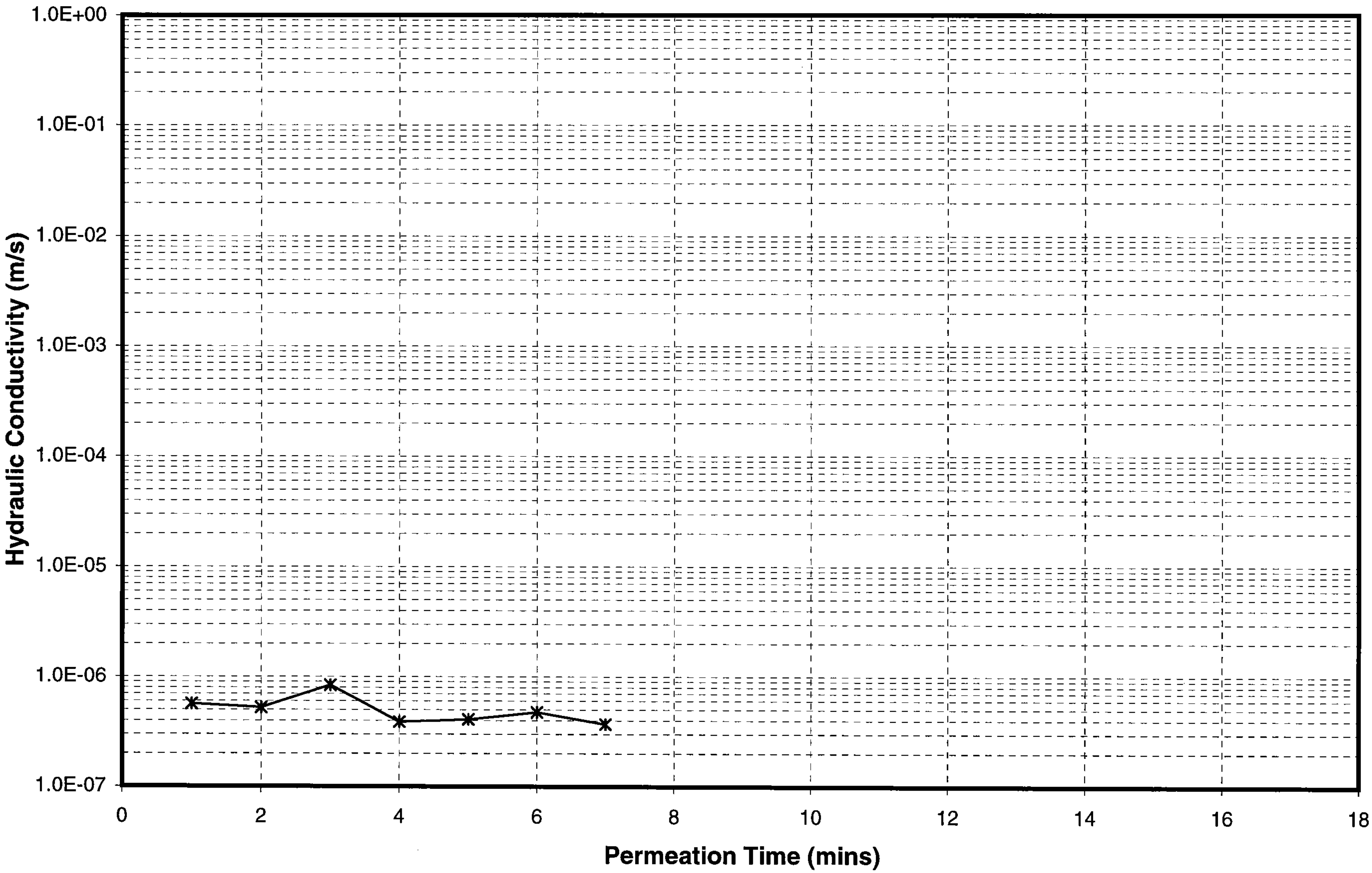
Figure D-11
Sheet 1 of 2

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-90)

SHANNON & WILSON, INC.
Geotechnical & Environmental Consultants

Project	Brightwater	Job No.	21-1-09869-001		
Boring No.	PB-12	Tested by	RJT	On	4/15/2003
Sample No.	S-26	Comp by	RJT	On	4/16/2003
Depth (ft)	96	Checked by		On	



PB12S26.xls Chart
5/20/2003 10:44 AM

Figure D-11
Sheet 2 of 2

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Project	Brightwater	Job No.	21-1-09869-001		
Boring No.	PB-12	Test By	RJT	On	04/16/03
Sample No.	S-40	Comp By	CKN	On	04/17/03
Depth, Ft.	131	Check By		On	

PERMEABILITY TEST ON GRANULAR SOIL
CONSTANT HEAD

ASTM D2434

Specimen Data

Height (cm)	11.65
Diameter (cm)	10.08
Area (cm^2)	79.82
Volume (cm^3)	929.52

Sample Classification

Dark gray, slightly silty, gravelly SAND (SM)

Permeameter Dimensions

I.D. of Reservior (cm)	10.08
O.D. of Tube (cm)	1.58
Area (cm^2)	77.85
Sample Length (cm)	11.65

Remarks

Moisture Content

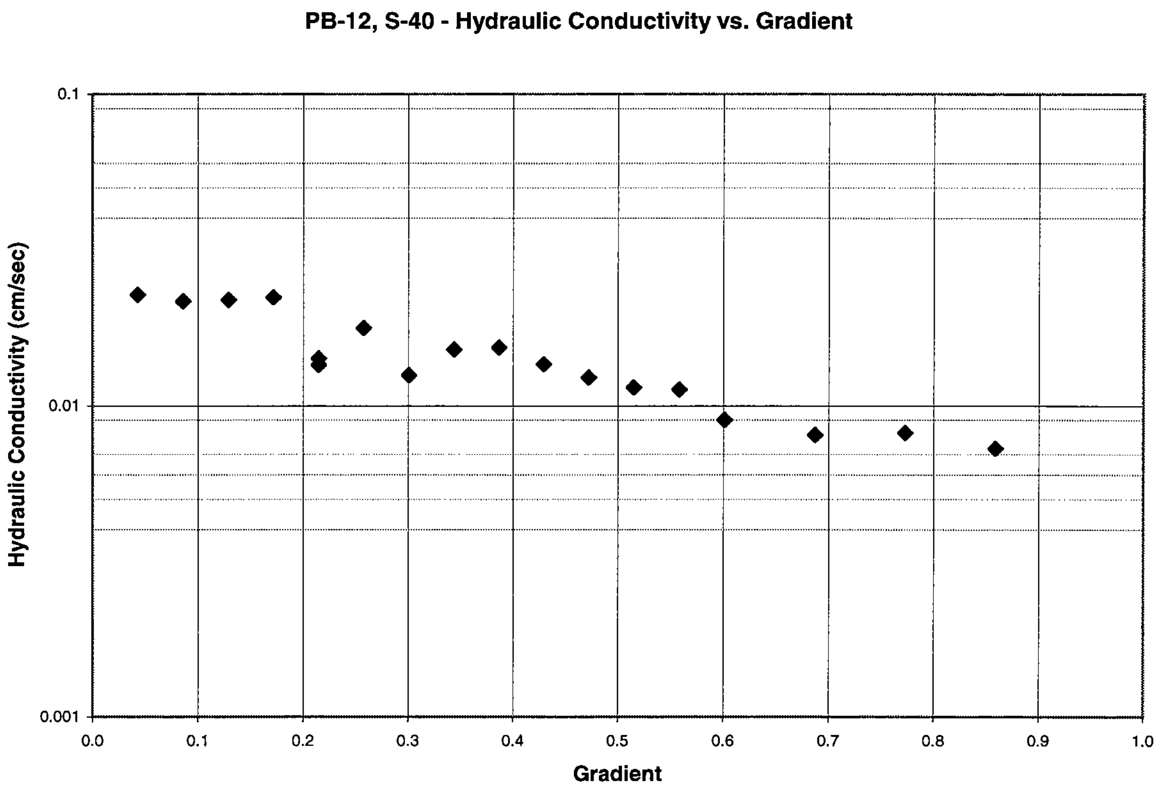
	Before	After
Wet + tare (g)	677.09	1957.06
Dry + tare (g)	627.74	1729.77
Tare (g)	111.86	101.92
mc (%)	9.6%	14.0%

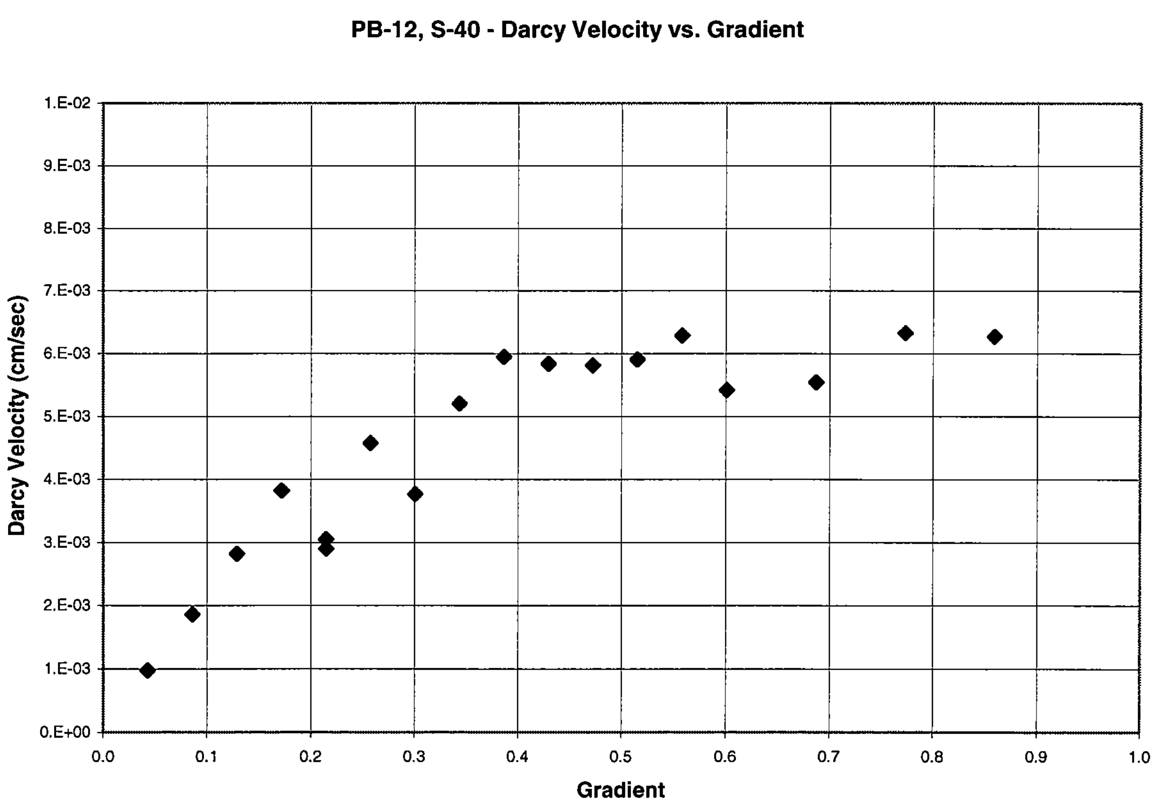
Density Determination

Initial Wet Weight (g)	1803.56
Final Wet Weight (g)	1855.14
Est. Specific Gravity	2.7
Dry Unit Weight, γ_d (pcf)	110.0
Compacted Unit Weight, γ_m (pcf)	122.0
Saturated Unit Weight, γ_{sat} (pcf)	125.4
Temperature (°C)	23

Test No.	Reservoir Level		Δh	H	t	Q	I	Q/at	k (cm/s)
	h_1 (cm)	h_2 (cm)	(cm)	(cm)	(s)	(cm^3)			
1	54.1	50.8	3.3	0.5	3300	256.9	0.04	9.8E-04	2.3E-02
2	50.8	46.8	4.0	1.0	2100	311.4	0.09	1.9E-03	2.2E-02
3	46.7	44.1	2.6	1.5	900	202.4	0.13	2.8E-03	2.2E-02
4	44.1	39.4	4.7	2.0	1200	365.9	0.17	3.8E-03	2.2E-02
5	39.4	36.4	3.0	2.5	960	233.6	0.21	3.0E-03	1.4E-02
6	53.7	47.1	6.6	2.5	2220	513.8	0.21	2.9E-03	1.4E-02
7	47.1	40.2	6.9	3.0	1470	537.2	0.26	4.6E-03	1.8E-02
8	52	43.2	8.8	3.5	2280	685.1	0.30	3.8E-03	1.3E-02
9	43.1	38.3	4.8	4.0	900	373.7	0.34	5.2E-03	1.5E-02
10	37.1	25.4	11.7	4.5	1920	910.9	0.39	5.9E-03	1.5E-02
11	51	43.1	7.9	5.0	1320	615.1	0.43	5.8E-03	1.4E-02
12	43.1	12.7	30.4	5.5	5100	2366.8	0.47	5.8E-03	1.2E-02
13	52.8	45.9	6.9	6.0	1140	537.2	0.52	5.9E-03	1.1E-02
14	44.6	33	11.6	6.5	1800	903.1	0.56	6.3E-03	1.1E-02
15	54	36.5	17.5	7.0	3150	1362.5	0.60	5.4E-03	9.0E-03
16	53.3	45.8	7.5	8.0	1320	583.9	0.69	5.5E-03	8.1E-03
17	45.6	34.7	10.9	9.0	1680	848.6	0.77	6.3E-03	8.2E-03
18	53.2	45.1	8.1	10.0	1260	630.6	0.86	6.3E-03	7.3E-03
								Average k	1.4E-02

Note:
h_1 is the initial reservoir water level.
h_2 is the final reservoir water level.
Δh is the change in reservoir water level during the test.
H is the head difference across the specimen.
t is the elapse time for changing water level.
Q is the volume of water discharged.
I is the hydraulic gradient.
a is the cross-section area of the specimen.
k is the hydraulic conductivity of the specimen.


PB-12, S-40 - Hydraulic Conductivity vs. Gradient
0.1
0.01
0.001
Hydraulic Conductivity (cm/sec)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Gradient


PB-12, S-40 - Darcy Velocity vs. Gradient
1.E-02
9.E-03
8.E-03
7.E-03
6.E-03
5.E-03
4.E-03
3.E-03
2.E-03
1.E-03
0.E+00
Darcy Velocity (cm/sec)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Gradient

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-90)

SHANNON & WILSON, INC.
Geotechnical & Environmental Consultants

Project	Brightwater	Job No.	21-1-09869-001		
Boring No.	PB-12	Tested by	RJT	On	4/28/2003
Sample No.	S-51	Comp by	RJT	On	4/28/2003
Depth (ft)	160	Checked by		On	

WATER CONTENT DATA:

	Before Test	After Test
Pan No.	X-1	Z-44
Wet+Tare	644.33	763.38
Dry+Tare	593.66	682.35
Tare	110.38	110.36
WC, %	10.5	14.2

SPECIMEN DATA:

	Before Test	After Consol.	After Test
Height, m	0.0721	0.0714	0.0713
Diameter, m	0.0724	0.0724	0.0724
Wet Weight, g	628.4	653.95	653.95
Volume, ml	296.8	294.1	293.6
Area, m^2	0.00412	0.00412	0.00412
Wet Unit Wt, pcf	132.1	138.7	139.0
Dry Unit Wt, pcf	119.6	121.5	121.7
Est. Saturation,%	68.0	97.2	97.8

OTHER INFORMATION:

Burette Corr. Factor, BCF (vol. to height), 1ml = 0.0047 m

a = 2.13E-04 m^2

Specific Gravity ☑ Assumed ☐ Measured = 2.72

B-Coefficient = 1.00

Volume of Solid = 209.1 ml

Pore Volume (P.V.)= 87.7 ml

Begin Saturation

Begin Consolidation

Begin Permeation

Soil Classification: Gray, gravelly, silty SAND; SM

FALLING-HEAD INCREASING TAILWATER LEVEL HYDRAULIC CONDUCTIVITY CALCULATION (METHOD C):

$$k = \frac{aL}{2At}\ln\left(\frac{h_1}{h_2}\right)$$

$$k_{20} = R_T k$$

a = cross-sectional area of standpipe, m^2
L = length of the sample, m
A = cross-sectional area of the sample, m^2
t = elapsed time between determination of h_1 and h_2, sec.

h_1 = head loss across the specimen at time t_1, m,
h_2 = head loss across the specimen at time t_2, m,
k_{20} = corrected hydraulic conductivity at temperature of 20 °C
R_T = correction factor for viscosity of water at various temperatures, T = (-0.02452*T+1.495)

MEASURED DATA:

Read Time			Elapsed Time	Temp T	Pressure Readings			Burette Readings						Head Loss h	Effective Stresses		Calculated Flow Volumes				Gradient (i)	k_{20}
					P_{cell}	P_{in}	P_{out}	V_{cell}	V_{in}	V_{out}	H_{cell}	H_{in}	H_{out}		σ'_{max}	σ'_{min}	Inflow	Outflow	Storage	Cum.		
day	hr	min	(hr)	(°C)	(psi)	(psi)	(psi)	(ml)	(ml)	(ml)	(m)	(m)	(m)	(m)	(psi)	(psi)	(ml)	(ml)	(ml)	P.V.		(m/sec)
1		0	0	23.0	112.2	40.0	40.0	84.9	99.6	0.0	0.399	0.468	0.000	0.396	72.7	72.1				0	5.5	
1		1	0.0167	23.0	112.2	40.0	40.0	84.9	94.3	6.3	0.399	0.443	0.030	0.342	72.6	72.1	5.3	6.3	-1.0	0.0661	4.7	4.3E-06
1		2	0.0333	23.0	112.2	40.0	40.0	84.9	88.3	12.3	0.399	0.415	0.058	0.285	72.6	72.2	6.0	6.0	0.0	0.1345	4.0	5.2E-06
1		3	0.05	23.0	112.2	40.0	40.0	84.9	83.0	17.8	0.399	0.390	0.084	0.234	72.5	72.2	5.3	5.5	-0.2	0.1961	3.3	5.7E-06
1		4	0.0667	23.0	112.2	40.0	40.0	84.9	78.2	22.2	0.399	0.368	0.104	0.191	72.5	72.2	4.8	4.4	0.4	0.2485	2.7	5.9E-06
1		5	0.0833	23.0	112.2	40.0	40.0	84.9	73.8	26.5	0.399	0.347	0.125	0.150	72.5	72.3	4.4	4.3	0.1	0.2981	2.1	7.0E-06
																					Average for last 4:	5.9E-06

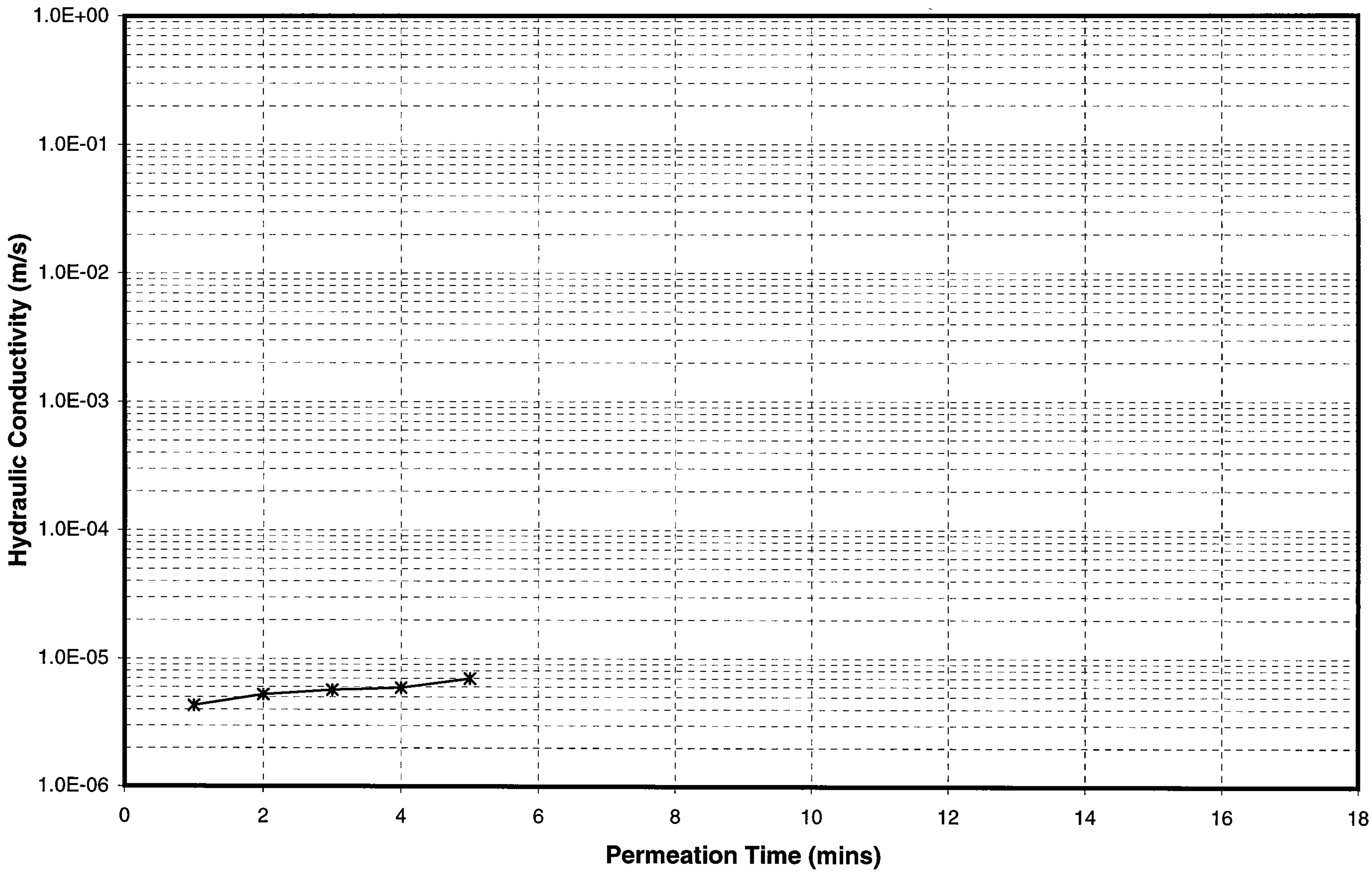
PB12S51.xls Data
5/20/2003 10:47 AM

Figure D-13
Sheet 1 of 2

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-90)

SHANNON & WILSON, INC.
Geotechnical & Environmental Consultants

Project	Brightwater	Job No.	21-1-09869-001		
Boring No.	PB-12	Tested by	RJT	On	4/28/2003
Sample No.	S-51	Comp by	RJT	On	4/28/2003
Depth (ft)	160	Checked by		On	



HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-90)

SHANNON & WILSON, INC.
Geotechnical & Environmental Consultants

Project	Brightwater	Job No.	21-1-09869-001		
Boring No.	PB-12	Tested by	RJT	On	4/24/2003
Sample No.	S-64	Comp by	RJT	On	4/24/2003
Depth (ft)	203.2	Checked by		On	

WATER CONTENT DATA:

	Before Test	After Test
Pan No.	K-2	E-20
Wet+Tare	72.51	678.68
Dry+Tare	60.30	575.22
Tare	3.08	101.82
WC, %	21.3	21.9

SPECIMEN DATA:

	Before Test	After Consol.	After Test
Height, m	0.0713	0.0708	0.0703
Diameter, m	0.0709	0.0709	0.0709
Wet Weight, g	584.08	577.04	577.04
Volume, ml	281.5	281.5	281.5
Area, m^2	0.00395	0.00395	0.00395
Wet Unit Wt, pcf	129.5	127.9	127.9
Dry Unit Wt, pcf	106.7	105.0	105.0
Est. Saturation,%	98.3	96.4	96.4

OTHER INFORMATION:

Burette Corr. Factor, BCF (vol. to height), 1ml = 0.0047 m
a = 2.13E-04 m^2
Specific Gravity ☑ Assumed ☐ Measured = 2.72
B-Coefficient = 0.97
Volume of Solid = 177.0 ml
Pore Volume (P.V.)= 104.5 ml
Begin Saturation
Begin Consolidation
Begin Permeation

Soil Classification: Gray, fine sandy, clayey SILT; ML

FALLING-HEAD INCREASING TAILWATER LEVEL HYDRAULIC CONDUCTIVITY CALCULATION (METHOD C):

$$k = \frac{aL}{2At}\ln\left(\frac{h_1}{h_2}\right)$$

$$k_{20} = R_T k$$

a = cross-sectional area of standpipe, m^2
L = length of the sample, m
A = cross-sectional area of the sample, m^2
t = elapsed time between determination of h_1 and h_2, sec.

h_1 = head loss across the specimen at time t_1, m,
h_2 = head loss across the specimen at time t_2, m,
k_{20} = corrected hydraulic conductivity at temperature of 20 °C
R_T = correction factor for viscosity of water at various temperatures, T
= (-0.02452*T+1.495)

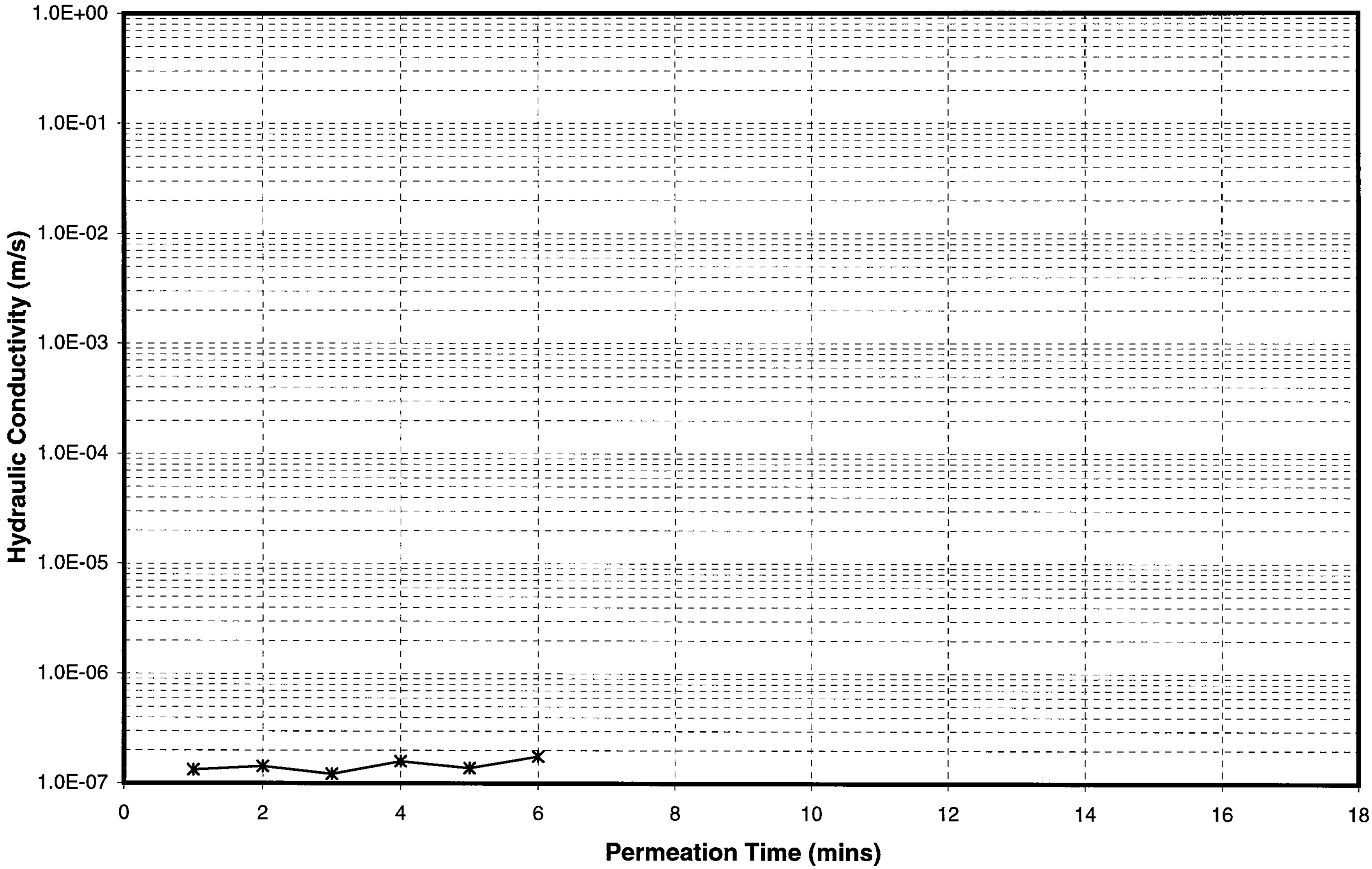
MEASURED DATA:

Read Time			Elapsed Time	Temp T	Pressure Readings			Burette Readings						Head Loss h	Effective Stresses		Calculated Flow Volumes				Gradient (i)	k_{20}
day	hr	min	(hr)	(°C)	P_{cell} (psi)	P_{in} (psi)	P_{out} (psi)	V_{cell} (ml)	V_{in} (ml)	V_{out} (ml)	H_{cell} (m)	H_{in} (m)	H_{out} (m)	(m)	σ'_{max} (psi)	σ'_{min} (psi)	Inflow (ml)	Outflow (ml)	Storage (ml)	Cum. P.V.		(m/sec)
1		0	0	23.0	136.0	45.0	45.0	84.0	98.3	2.5	0.395	0.462	0.012	0.379	91.4	90.9				0	5.3	
1		12	0.20	23.0	136.0	45.0	45.0	84.0	96.4	4.8	0.395	0.453	0.023	0.359	91.4	90.9	1.9	2.3	-0.4	0.0201	5.0	1.3E-07
1		30	0.50	23.0	136.0	45.0	45.0	84.0	93.2	7.9	0.395	0.438	0.037	0.330	91.4	90.9	3.2	3.1	0.1	0.0502	4.6	1.4E-07
1		40	0.67	23.0	136.0	45.0	45.0	84.0	91.7	9.2	0.395	0.431	0.043	0.316	91.4	90.9	1.5	1.3	0.2	0.0636	4.4	1.2E-07
1		53	0.88	23.0	136.0	45.0	45.0	84.0	89.5	11.5	0.395	0.421	0.054	0.295	91.4	91.0	2.2	2.3	-0.1	0.0851	4.1	1.6E-07
1		60	1.00	23.0	136.0	45.0	45.0	84.0	88.5	12.5	0.395	0.416	0.059	0.286	91.4	91.0	1.0	1.0	0.0	0.0947	4.0	1.4E-07
1		73	1.22	23.0	136.0	45.0	45.0	84.0	86.3	14.8	0.395	0.406	0.070	0.265	91.4	91.0	2.2	2.3	-0.1	0.1162	3.7	1.8E-07
																					Average for last 4:	1.5E-07

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-90)

SHANNON & WILSON, INC.
Geotechnical & Environmental Consultants

Project	Brightwater	Job No.	21-1-09869-001		
Boring No.	PB-12	Tested by	RJT	On	4/24/2003
Sample No.	S-64	Comp by	RJT	On	4/24/2003
Depth (ft)	203.2	Checked by		On	



PB12S64.xls Chart
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Figure D-14
Sheet 2 of 2

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER (ASTM Designation D 5084-90)

SHANNON & WILSON, INC.
Geotechnical & Environmental Consultants

Project	Brightwater	Job No.	21-1-09869-001		
Boring No.	PB-12	Tested by	RJT	On	4/24/2003
Sample No.	S-89	Comp by	RJT	On	4/24/2003
Depth (ft)	285.3	Checked by		On	

WATER CONTENT DATA:

	Before Test	After Test
Pan No.	K-1	E-24
Wet+Tare	66.35	609.96
Dry+Tare	56.06	528.68
Tare	3.22	101.89
WC, %	19.5	19.0

SPECIMEN DATA:

	Before Test	After Consol.	After Test
Height, m	0.0678	0.0680	0.0678
Diameter, m	0.0671	0.06712	0.06712
Wet Weight, g	514.82	508.40	508.40
Volume, ml	239.9	240.7	240.0
Area, m^2	0.00354	0.00354	0.00354
Wet Unit Wt, pcf	133.9	131.8	132.2
Dry Unit Wt, pcf	112.1	110.7	111.0
Est. Saturation,%	103.0	97.2	98.0

OTHER INFORMATION:

Burette Corr. Factor, BCF (vol. to height), 1ml = 0.0047 m
a = 2.13E-04 m^2
Specific Gravity ☑ Assumed ☐ Measured = 2.72
B-Coefficient = 1.00
Volume of Solid = 158.4 ml
Pore Volume (P.V.)= 81.5 ml
Begin Saturation
Begin Consolidation
Begin Permeation

Soil Classification: Gray, fine sandy, silty CLAY; CL

FALLING-HEAD INCREASING TAILWATER LEVEL HYDRAULIC CONDUCTIVITY CALCULATION (METHOD C):

$$k=\frac{aL}{2At}\ln\left(\frac{h_1}{h_2}\right)$$

$$k_{20}=R_T k$$

a = cross-sectional area of standpipe, m^2
L = length of the sample, m
A = cross-sectional area of the sample, m^2
t = elapsed time between determination of h_1 and h_2, sec.

h_1 = head loss across the specimen at time t_1, m,
h_2 = head loss across the specimen at time t_2, m,
k_{20} = corrected hydraulic conductivity at temperature of 20 °C
R_T = correction factor for viscosity of water at various temperatures, T = (-0.02452*T+1.495)

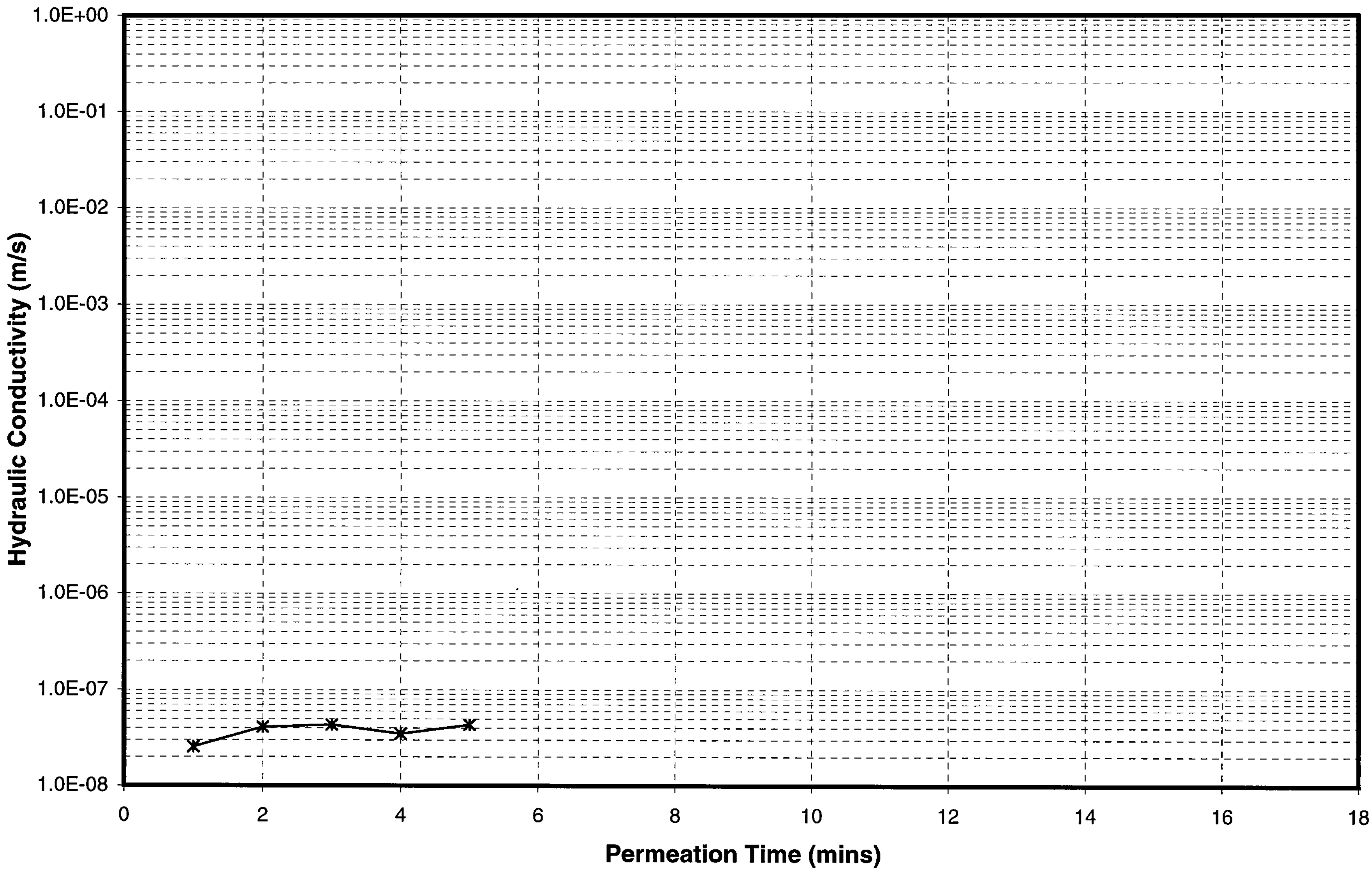
MEASURED DATA:

Read Time			Elapsed Time	Temp T	Pressure Readings			Burette Readings						Head Loss h	Effective Stresses		Calculated Flow Volumes				Gradient (i)	k_{20}
					P_{cell}	P_{in}	P_{out}	V_{cell}	V_{in}	V_{out}	H_{cell}	H_{in}	H_{out}		σ'_{max}	σ'_{min}	Inflow	Outflow	Storage	Cum.		
day	hr	min	(hr)	(°C)	(psi)	(psi)	(psi)	(ml)	(ml)	(ml)	(m)	(m)	(m)	(m)	(psi)	(psi)	(ml)	(ml)	(ml)	P.V.		(m/sec)
1		0	0	23.0	171.0	45.0	45.0	43.8	100.1	0.5	0.206	0.470	0.002	0.400	126.2	125.6				0	5.9	
1		25	0.42	23.0	171.0	45.0	45.0	43.8	99.8	1.9	0.206	0.469	0.009	0.392	126.2	125.6	0.3	1.4	-1.1	0.0104	5.8	2.6E-08
1		40	0.67	23.0	171.0	45.0	45.0	43.8	99.0	2.7	0.206	0.465	0.013	0.385	126.2	125.6	0.8	0.8	0.0	0.0203	5.7	4.1E-08
1		49	0.82	23.0	171.0	45.0	45.0	43.8	98.5	3.2	0.206	0.463	0.015	0.380	126.2	125.6	0.5	0.5	0.0	0.0264	5.6	4.3E-08
1		66	1.10	23.0	171.0	45.0	45.0	43.8	97.8	4.0	0.206	0.460	0.019	0.373	126.2	125.6	0.7	0.8	-0.1	0.0356	5.5	3.5E-08
1		80	1.33	23.0	171.0	45.0	45.0	43.8	97.1	4.8	0.206	0.456	0.023	0.366	126.2	125.6	0.7	0.8	-0.1	0.0448	5.4	4.3E-08
																					Average for last 4:	4.1E-08

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-90)

SHANNON & WILSON, INC.
Geotechnical & Environmental Consultants

Project	Brightwater	Job No.	21-1-09869-001		
Boring No.	PB-12	Tested by	RJT	On	4/24/2003
Sample No.	S-89	Comp by	RJT	On	4/24/2003
Depth (ft)	285.3	Checked by		On	



PB12S89.xls Chart
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Figure D-15
Sheet 2 of 2

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-90)

SHANNON & WILSON, INC.
Geotechnical & Environmental Consultants

Project	Brightwater	Job No.	21-1-09869-001		
Boring No.	PB-12	Tested by	RJT	On	4/24/2003
Sample No.	S-102	Comp by	RJT	On	4/24/2003
Depth (ft)	331.7	Checked by		On	

WATER CONTENT DATA:

	Before Test	After Test
Pan No.	K-3	Z-22
Wet+Tare	64.99	533.57
Dry+Tare	53.31	467.06
Tare	2.99	162.43
WC, %	23.2	21.8

SPECIMEN DATA:

	Before Test	After Consol.	After Test
Height, m	0.0612	0.0601	0.0600
Diameter, m	0.0614	0.0614	0.0614
Wet Weight, g	374.99	371.22	371.22
Volume, ml	181.2	178.0	177.7
Area, m^2	0.00296	0.00296	0.00296
Wet Unit Wt, pcf	129.1	130.2	130.4
Dry Unit Wt, pcf	104.8	106.8	107.0
Est. Saturation,%	101.9	100.9	101.3

OTHER INFORMATION:

Burette Corr. Factor, BCF (vol. to height), 1ml = 0.0047 m

a = 2.13E-04 m^2

Specific Gravity ☑ Assumed ☐ Measured = 2.72

B-Coefficient = 1.00

Volume of Solid = 111.9 ml

Pore Volume (P.V.)= 69.3 ml

Begin Saturation

Begin Consolidation

Begin Permeation

Soil Classification: Dark gray, fine sandy, clayey SILT; ML

FALLING-HEAD INCREASING TAILWATER LEVEL HYDRAULIC CONDUCTIVITY CALCULATION (METHOD C):

$$k = \frac{aL}{2At}\ln\left(\frac{h_1}{h_2}\right)$$

$$k_{20} = R_T k$$

a = cross-sectional area of standpipe, m^2
L = length of the sample, m
A = cross-sectional area of the sample, m^2
t = elapsed time between determination of h_1 and h_2, sec.

h_1 = head loss across the specimen at time t_1, m,
h_2 = head loss across the specimen at time t_2, m,
k_{20} = corrected hydraulic conductivity at temperature of 20 °C
R_T = correction factor for viscosity of water at various temperatures, T = (-0.02452*T+1.495)

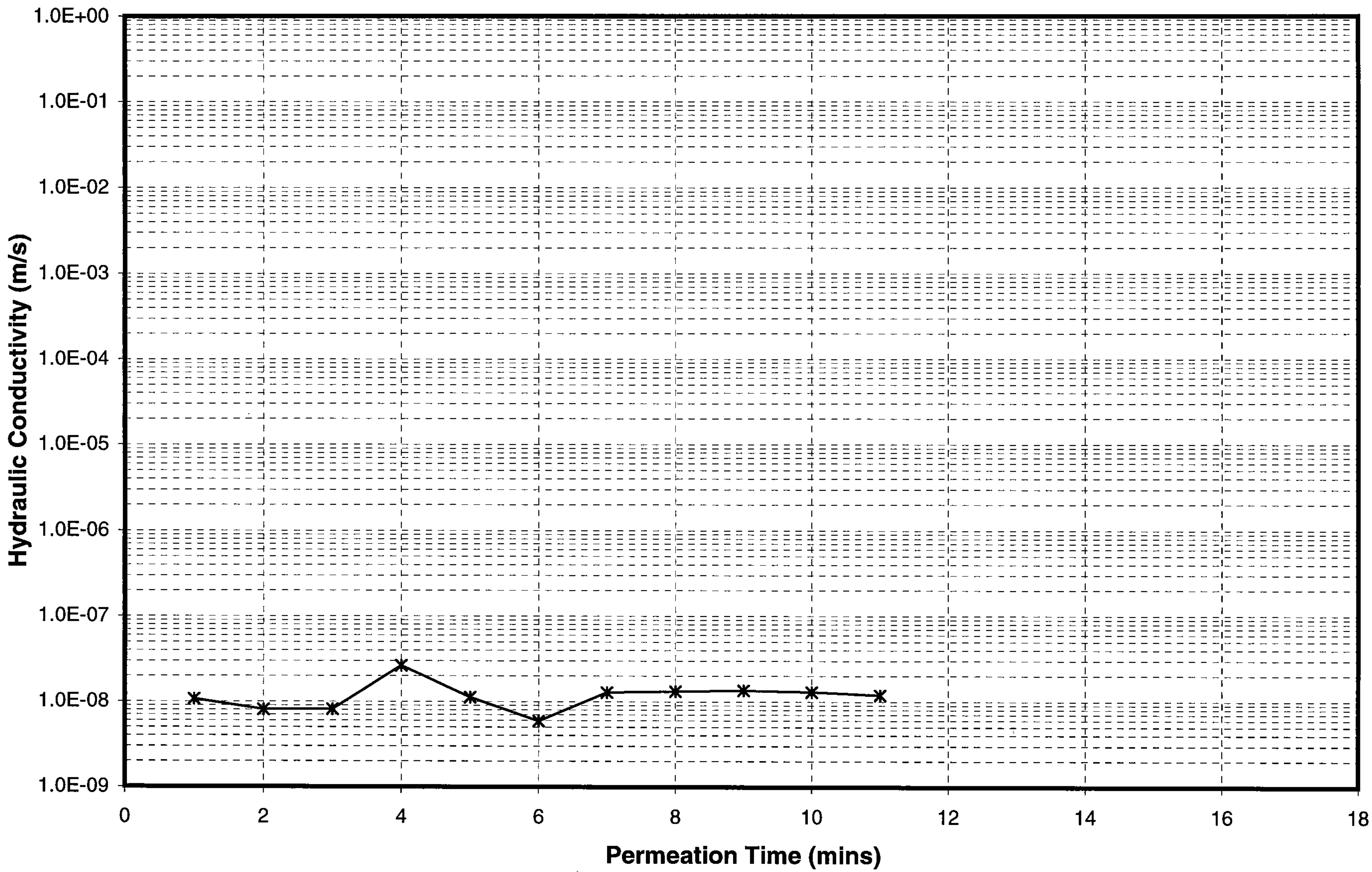
MEASURED DATA:

Read Time day	Read Time hr	Read Time min	Elapsed Time (hr)	Temp T (°C)	Pressure Readings P_{cell} (psi)	P_{in} (psi)	P_{out} (psi)	Burette Readings V_{cell} (ml)	V_{in} (ml)	V_{out} (ml)	H_{cell} (m)	H_{in} (m)	H_{out} (m)	Head Loss h (m)	Effective Stresses σ'_{max} (psi)	σ'_{min} (psi)	Calculated Flow Volumes Inflow (ml)	Outflow (ml)	Storage (ml)	Cum. P.V.	Gradient (i)	k_{20} (m/sec)
1		0	0	23.0	192.0	45.0	45.0	81.2	99.8	0.8	0.382	0.469	0.004	0.404	147.4	146.9				0	6.6	
1		30	0.5	23.0	192.0	45.0	45.0	81.2	99.2	1.0	0.382	0.466	0.005	0.400	147.4	146.9	0.6	0.2	0.4	0.0058	6.5	1.1E-08
1		50	0.8333	23.0	192.0	45.0	45.0	81.2	99.0	1.2	0.382	0.465	0.006	0.398	147.4	146.9	0.2	0.2	0.0	0.0087	6.5	8.0E-09
1		65	1.0833	23.0	192.0	45.0	45.0	81.2	98.9	1.4	0.382	0.465	0.007	0.397	147.4	146.9	0.1	0.2	-0.1	0.0108	6.5	8.1E-09
1		82	1.3667	23.0	192.0	45.0	45.0	81.2	98.4	2.0	0.382	0.462	0.009	0.392	147.4	146.9	0.5	0.6	-0.1	0.0188	6.4	2.6E-08
1		104	1.7333	23.0	192.0	45.0	45.0	81.2	98.1	2.3	0.382	0.461	0.011	0.389	147.4	146.9	0.3	0.3	0.0	0.0231	6.4	1.1E-08
1		118	1.9667	23.0	192.0	45.0	45.0	81.2	98.0	2.4	0.382	0.461	0.011	0.388	147.4	146.9	0.1	0.1	0.0	0.0245	6.3	5.9E-09
1		131	2.1833	23.0	192.0	45.0	45.0	81.2	97.8	2.6	0.382	0.460	0.012	0.386	147.4	146.9	0.2	0.2	0.0	0.0274	6.3	1.3E-08
1		182	3.0333	23.0	192.0	45.0	45.0	81.2	97.0	3.4	0.382	0.456	0.016	0.379	147.4	146.9	0.8	0.8	0.0	0.0390	6.2	1.3E-08
1		220	3.6667	23.0	192.0	45.0	45.0	81.2	96.4	4.0	0.382	0.453	0.019	0.373	147.4	146.9	0.6	0.6	0.0	0.0476	6.1	1.3E-08
1		240	4	23.0	192.0	45.0	45.0	81.2	96.1	4.3	0.382	0.452	0.020	0.370	147.4	146.9	0.3	0.3	0.0	0.0519	6.1	1.3E-08
1		262	4.3667	23.0	192.0	45.0	45.0	81.2	95.8	4.6	0.382	0.450	0.022	0.367	147.4	146.9	0.3	0.3	0.0	0.0563	6.0	1.2E-08
																					Average for last 4:	1.3E-08

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-90)

SHANNON & WILSON, INC.
Geotechnical & Environmental Consultants

Project	Brightwater	Job No.	21-1-09869-001		
Boring No.	PB-12	Tested by	RJT	On	4/24/2003
Sample No.	S-102	Comp by	RJT	On	4/24/2003
Depth (ft)	331.7	Checked by		On	



PB12S102.xls Chart
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Figure D-16
Sheet 2 of 2

BETA

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Beta Analytic Inc.
4985 SW 74 Court
Miami, Florida 33155 USA
Tel: 305 667 5167
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beta@radiocarbon.com
www.radiocarbon.com

MR. DARDEN HOOD
Director

Mr. Ronald Hatfield
Mr. Christopher Patrick
Deputy Directors

May 15, 2003

Mr. Ted Hopkins
Shannon and Wilson, Incorporated
P.O. Box 300303
400 North 34th Street, Suite 100
Seattle, WA 98103
USA

RE: Radiocarbon Dating Results For Samples 21109869001-128, 21109869001-197

Dear Mr. Hopkins:

Enclosed are the radiocarbon dating results for two samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses went normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

Thank you for prepaying the analyses. A receipt is enclosed. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood

BETA

BETA ANALYTIC INC.

DR. M.A. TAMERS and MR. D.G. HOOD

UNIVERSITY BRANCH
4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305/667-5167 FAX: 305/663-0964
E-MAIL: beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Mr. Ted Hopkins — Report Date: 5/15/2003

Shannon and Wilson, Incorporated — Material Received: 4/21/2003

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 178512 SAMPLE : 21109869001-128 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (wood): acid/alkali/acid	50290 +/- 0 BP	-25.3 o/oo	> 50290 BP
Beta - 178513 SAMPLE : 21109869001-197 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (wood): acid/alkali/acid	50310 +/- 0 BP	-26.4 o/oo	> 50290 BP

Dates are reported as RCYBP (radiocarbon years before present, "present" = 1950A.D.). By International convention, the modern reference standard was 95% of the C14 content of the National Bureau of Standards' Oxalic Acid & calculated using the Libby C14 half life (5568 years). Quoted errors represent 1 standard deviation statistics (68% probability) & are based on combined measurements of the sample, background, and modern reference standards.

Measured C13/C12 ratios were calculated relative to the PDB-1 international standard and the RCYBP ages were normalized to -25 per mil. If the ratio and age are accompanied by an (*), then the C13/C12 value was estimated, based on values typical of the material type. The quoted results are NOT calibrated to calendar years. Calibration to calendar years should be calculated using the Conventional C14 age.

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Dr. MURRY A. TAMERS
Mr. DARDEN G. HOOD
Directors

Mr. RONALD E. HATFIELD
Mr. CHRISTOPHER L. PATRICK
Deputy Directors

ANALYTICAL PROCEDURES AND FINAL REPORT

Final Report

The final report package includes the final date report, a statement outlining our analytical procedures, a glossary of pretreatment terms, calendar calibration information, billing documents (containing balance/credit information and the number of samples submitted within the yearly discount period), and peripheral items to use with future submittals. The final report includes the individual analysis method, the delivery basis, the material type and the individual pretreatments applied. The final report will be sent by mail, fax or e-mail, where available.

Pretreatment

Pretreatment methods are reported along with each result. All necessary chemical and mechanical pretreatments of the submitted material are applied at the laboratory to isolate ^{14}C which may best represent the time event of interest. When interpreting the results, it is important to consider the pretreatments. Some samples cannot be fully pretreated, making their ^{14}C ages more subjective than samples which can be fully pretreated. Some materials receive no pretreatments. Please read the pretreatment glossary.

Analysis

Materials measured by the radiometric technique are analyzed by synthesizing sample carbon to benzene (92% C), measuring for ^{14}C content in a scintillation spectrometer, and then calculating for radiocarbon age. If the Extended Counting Service is used, the ^{14}C content is measured for a greatly extended period of time. AMS results are derived from reduction of sample carbon to graphite (100 %C), along with standards and backgrounds. The graphite is then detected for ^{14}C content in an accelerator-mass-spectrometer (AMS) located at one of 9 collaborating research facilities, who return the raw data to us for verification, isotopic fractionation correction, calculation calendar calibration, and reporting.

The Radiocarbon Age and Calendar Calibration

The "Conventional ^{14}C Age (*)" is the result after applying $^{13}C/^{12}C$ corrections to the measured age and is the most appropriate radiocarbon age (the "*" is discussed at the bottom of the final report). Applicable calendar calibrations are included for materials 0 and about 20,000 BP. If certain calibrations are not included with a report, the results were either too young, too old, or inappropriate for calibration.

PRETREATMENT GLOSSARY

Pretreatment of submitted materials is required to eliminate secondary carbon components. These components, if not eliminated, could result in a radiocarbon date which is too young or too old. Pretreatment does not ensure that the radiocarbon date will represent the time event of interest. This is determined by the sample integrity. The old wood effect, burned intrusive roots, bioturbation, secondary deposition, secondary biogenic activity incorporating recent carbon (bacteria) and the analysis of multiple components of differing age are just some examples of potential problems. The pretreatment philosophy is to reduce the sample to a single component, where possible, to minimize the added subjectivity associated with these types of problems.

"acid/alkali/acid"

The sample was first gently crushed/dispersed in deionized water. It was then given hot HCl acid washes to eliminate carbonates and alkali washes (NaOH) to remove secondary organic acids. The alkali washes were followed by a final acid rinse to neutralize the solution prior to drying. Chemical concentrations, temperatures, exposure times, and number of repetitions, were applied accordingly with the uniqueness of the sample. Each chemical solution was neutralized prior to application of the next. During these serial rinses, mechanical contaminants such as associated sediments and rootlets were eliminated. This type of pretreatment is considered a "full pretreatment". On occasion the report will list the pretreatment as "acid/alkali/acid - insolubles" to specify which fraction of the sample was analyzed. This is done on occasion with sediments (See "acid/alkali/acid - solubles"

Typically applied to: charcoal, wood, some peats, some sediments, textiles

"acid/alkali/acid - solubles"

On occasion the alkali soluble fraction will be analyzed. This is a special case where soil conditions imply that the soluble fraction will provide a more accurate date. It is also used on some occasions to verify the present/absence or degree of contamination present from secondary organic acids. The sample was first pretreated with acid to remove any carbonates and to weaken organic bonds. After the alkali washes (as discussed above) are used, the solution containing the alkali soluble fraction is isolated/filtered and combined with acid. The soluble fraction which precipitates is rinsed and dried prior to combustion.

"acid washes"

Surface area was increased as much a possible. Solid chunks were crushed, fibrous materials were shredded, and sediments were dispersed. Acid (HCl) was applied repeatedly to ensure the absence of carbonates. Chemical concentrations, temperatures, exposure times, and number of repetitions, were applied accordingly with the uniqueness of each sample. The sample, for a number of reasons, could not be subjected to alkali washes to ensure the absence of secondary organic acids. The most common reason is that the primary carbon is soluble in the alkali. Dating results reflect the total organic content of the analyzed material. Their accuracy depends on the researcher's ability to subjectively eliminate potential contaminants based on contextual facts.

Typically applied to: organic sediments, some peats, small wood or charcoal, special cases

"collagen extraction"

The material was first tested for friability ("softness"). Very soft bone material is an indication of the potential absence of the collagen fraction (basal bone protein acting as a "reinforcing agent" within the crystalline apatite structure). It was then washed in de-ionized water and gently crushed. Dilute, cold HCl acid was repeatedly applied and replenished until the mineral fraction (bone apatite) was eliminated. The collagen was then dissected and inspected for rootlets. Any rootlets present were also removed when replenishing the acid solutions. Where possible, usually dependant on the amount of collagen available, alkali (NaOH) was also applied to ensure the absence of secondary organic acids.

Typically applied to: bones

"acid etch"

The calcareous material was first washed in de-ionized water, removing associated organic sediments and debris (where present). The material was then crushed/dispersed and repeatedly subjected to HCl etches to eliminate secondary carbonate components. In the case of thick shells, the surfaces were physically abraded prior to etching down to a hard, primary core remained. In the case of porous carbonate nodules and caliche, very long exposure times were applied to allow infiltration of the acid. Acid exposure times, concentrations, and number of repetitions, were applied accordingly with the uniqueness of the sample.

Typically applied to: shells, caliche, calcareous nodules

"neutralized"

Carbonates precipitated from ground water are usually submitted in an alkaline condition (ammonium hydroxide or sodium hydroxide solution). Typically this solution is neutralized in the original sample container, using deionized water. If larger volume dilution was required, the precipitate and solution were transferred to a sealed separatory flask and rinsed to neutrality. Exposure to atmosphere was minimal.

Typically applied to: Strontium carbonate, Barium carbonate
(i.e. precipitated ground water samples)

"none"

No laboratory pretreatments were applied. Special requests and pre-laboratory pretreatment usually accounts for this.

"acid/alkali/acid/cellulose extraction"

Following full acid/alkali/acid pretreatments, the sample is rinsed in NaClO2 under very controlled conditions (Ph = 3, temperature = 70 degrees C). This eliminates all components except wood cellulose. It is useful for woods which are either very old or highly contaminated.

Applied to: wood

"carbonate precipitation"

Dissolved carbon dioxide and carbonate species are precipitated from submitted water by complexing them as amonium carbonate. Strontium chloride is added to the ammonium carbonate solution and strontium carbonate is precipitated for the analysis. The result is representative of the dissolved inorganic carbon within the water. Results are reported as "water DIC".

Applied to: water

BETA ANALYTIC INC.
RADIOCARBON DATING LABORATORY
CALIBRATED C-14 DATING RESULTS

Calibrations of radiocarbon age determinations are applied to convert BP results to calendar years. The short term difference between the two is caused by fluctuations in the heliomagnetic modulation of the galactic cosmic radiation and, recently, large scale burning of fossil fuels and nuclear devices testing. Geomagnetic variations are the probable cause of longer term differences.

The parameters used for the corrections have been obtained through precise analyses of hundreds of samples taken from known-age tree rings of oak, sequoia, and fir up to about 10,000 BP. Calibration using tree-rings to about 12,000 BP is still being researched and provides somewhat less precise correlation. Beyond that, up to about 20,000 BP, correlation using a modeled curve determined from U/Th measurements on corals is used. This data is still highly subjective. Calibrations are provided up to about 19,000 years BP using the most recent calibration data available (Radiocarbon, Vol 40, No. 3, 1998).

The Pretoria Calibration Procedure (Radiocarbon, Vol 35, No. 1, 1993, pg 317) program has been chosen for these calendar calibrations. It uses splines through the tree-ring data as calibration curves, which eliminates a large part of the statistical scatter of the actual data points. The spline calibration allows adjustment of the average curve by a quantified closeness-of-fit parameter to the measured data points. A single spline is used for the precise correlation data available back to 9900 BP for terrestrial samples and about 6900 BP for marine samples. Beyond that, splines are taken on the error limits of the correlation curve to account for the lack of precision in the data points.

In describing our calibration curves, the solid bars represent one sigma statistics (68% probability) and the hollow bars represent two sigma statistics (95% probability). Marine carbonate samples that have been corrected for δ 13/12C, have also been corrected for both global and local geographic reservoir effects (as published in Radiocarbon, Volume 35, Number 1, 1993) prior to the calibration. Marine carbonates that have not been corrected for δ 13/12C are adjusted by an assumed value of 0 ‰ in addition to the reservoir corrections. Reservoir corrections for fresh water carbonates are usually unknown and are generally not accounted for in those calibrations. In the absence of measured δ 13/12C ratios, a typical value of -5 ‰ is assumed for freshwater carbonates.

(Caveat: the correlation curve for organic materials assume that the material dated was living for exactly ten years (e.g. a collection of 10 individual tree rings taken from the outer portion of a tree that was cut down to produce the sample in the feature dated). For other materials, the maximum and minimum calibrated age ranges given by the computer program are uncertain. The possibility of an "old wood effect" must also be considered, as well as the potential inclusion of younger or older material in matrix samples. Since these factors are indeterminant error in most cases, these calendar calibration results should be used only for illustrative purposes. In the case of carbonates, reservoir correction is theoretical and the local variations are real, highly variable and dependant on provenience. Since imprecision in the correlation data beyond 10,00 years is high, calibrations in this range are likely to change in the future with refinement in the correlation curve. The age ranges and especially the intercept ages generated by the program, must be considered as approximations.)

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

Variables used in the calculation of age calibration → (Variables: est. C13/C12=-25:lab. mult=1)

Laboratory number: **Beta-123456**

The uncalibrated Conventional Radiocarbon Age (± 1 sigma)

Conventional radiocarbon age[1]: **2400±60 BP**

The calendar age range in both calendar years (AD or BC) and in Radiocarbon Years (BP)

2 Sigma calibrated result: (95% probability) **Cal BC 770 to 380 (Cal BP 2720 to 2330)**

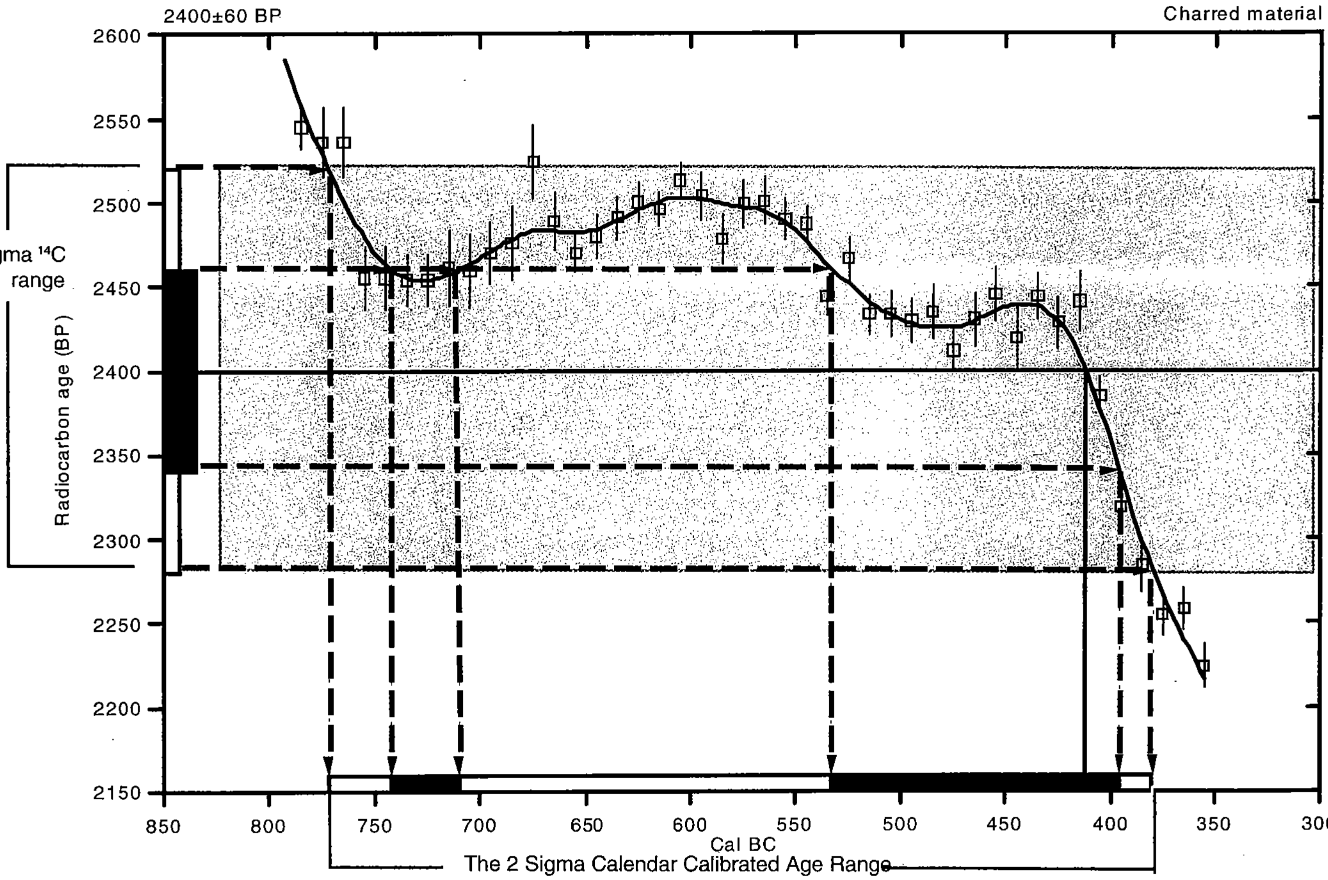
[1] *C13/C12 ratio estimated*

The intercept between the average radiocarbon age and the calibrated curve time scale. This value is illustrative and should not be used by itself.

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 410 (Cal BP 2360)

1 Sigma calibrated result: (68% probability) Cal BC 740 to 710 (Cal BP 2690 to 2660) and Cal BC 535 to 395 (Cal BP 2485 to 2345)



The 2 Sigma Calendar Calibrated Age Range

This range is determined by the portion of the curve that is in a "box" drawn from the 2 sigma limits on the radiocarbon age. If a section of the curve goes outside of the "box", multiple ranges will occur as shown by the two 1 sigma ranges which occur from sections going outside of a similar "box" which would be drawn at the 1 sigma limits.

References:

Database used
Intcal 98
Calibration Database
Editorial Comment
Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xiii
INTCAL98 Radiocarbon Age Calibration
Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083
Mathematics
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

References for the calibration data and the mathematics applied to the data. These references, as well as the Conventional Radiocarbon Age and the 13C/12C ratio used should be included in your papers.

Beta Analytic Radiocarbon Dating Laboratory

4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-mail: beta@radiocarbon.com

ATTACHMENT E

ENVIRONMENTAL LABORATORY TEST RESULTS

OnSite Environmental Inc.
Analytical Testing and Mobile Laboratory Services

April 3, 2003

Scott Gaulke
Shannon & Wilson, Inc.
400 N 34th Street, Suite 100
Seattle, WA 98103

Re: Analytical Data for Project 21-1-09869-001
Laboratory Reference No. 0304-026

Dear Scott:

Enclosed are the analytical results and associated quality control data for samples submitted on April 3, 2003.

The standard policy of OnSite Environmental Inc. is to store your samples for 30 days from the date of receipt. If you require longer storage, please contact the laboratory.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning the data, or need additional information, please feel free to call me.

Sincerely,

David Baumeister
Project Manager

Enclosures

14648 NE 95th Street, Redmond, WA 98052 • (425) 883-3881 • Fax (425) 885-4603

Date of Report: April 3, 2003
Samples Submitted: April 3, 2003
Lab Reference: 04-026
Project: 21-1-09869-001

Case Narrative

Samples were collected on April 3, 2003. Samples were maintained at the laboratory at 4°C and followed SW846 analysis and extraction methods.

NWTPH HCID Analysis

Any QA/QC issues associated with this extraction and analysis will be indicated with a footnote reference and discussed in detail on the Data Qualifier page.

Date of Report: April 3, 2003
Samples Submitted: April 3, 2003
Lab Reference: 04-026
Project: 21-1-09869-001

NWTPH-HCID

Date Extracted:	4-4-03
Date Analyzed:	4-4-03
Matrix:	Soil
Units:	mg/Kg (ppm)

Client ID:	PB-7B, S-1
Lab ID:	04-026-01
Gasoline:	ND
PQL:	24
Diesel Fuel:	ND
PQL:	59
Lube Oil:	ND
PQL:	120
Surrogate Recovery:	
o-Terphenyl	103%

Flags:

Date of Report: April 3, 2003
Samples Submitted: April 3, 2003
Lab Reference: 04-026
Project: 21-1-09869-001

NWTPH-HCID
METHOD BLANK QUALITY CONTROL

Date Extracted:	4-4-03
Date Analyzed:	4-4-03
Matrix:	Soil
Units:	mg/Kg (ppm)

Lab ID:	MB0404S1
Gasoline:	ND
PQL:	20
Diesel Fuel:	ND
PQL:	50
Lube Oil:	ND
PQL:	100
Surrogate Recovery:	
o-Terphenyl	108%
Flags	

Date of Report: April 3, 2003
Samples Submitted: April 3, 2003
Lab Reference: 04-026
Project: 21-1-09869-001

% MOISTURE

Date Analyzed: 4-4-03

Client ID	Lab ID	% Moisture
PB-7B, S-1	04-026-01	15

OnSite Environmental Inc.

Data Qualifiers and Abbreviations

A - Due to a high sample concentration, the amount spiked is insufficient for meaningful MS/MSD recovery data.

B - The analyte indicated was also found in the blank sample.

C - The duplicate RPD is outside control limits due to high result variability when analyte concentrations are within five times the quantitation limit.

D - Data from 1:____ dilution.

E - The value reported exceeds the quantitation range, and is an estimate.

F - Surrogate recovery data is not available due to the high concentration of coeluting target compounds.

G - Insufficient sample quantity for duplicate analysis.

H - The analyte indicated is a common laboratory solvent and may have been introduced during sample preparation, and be impacting the sample result.

I - Compound recovery is outside of the control limits.

J - The value reported was below the practical quantitation limit. The value is an estimate.

K - Sample duplicate RPD is outside control limits due to sample inhomogeniety. The sample was re-extracted and re-analyzed with similar results.

L - The RPD is outside of the control limits.

M - Hydrocarbons in the gasoline range (toluene-napthalene) are present in the sample.

O - Hydrocarbons outside the defined gasoline range are present in the sample.

P - The RPD of the detected concentrations between the two columns is greater than 40.

Q - Surrogate recovery is outside of the control limits.

S - Surrogate recovery data is not available due to the necessary dilution of the sample.

T - The sample chromatogram is not similar to a typical ____________.

U - The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

V - Matrix Spike/Matrix Spike Duplicate recoveries are outside control limits due to matrix effects.

W - Matrix Spike/Matrix Spike Duplicate RPD is outside control limits due to sample inhomogeniety.

X - Sample extract treated with a silica gel cleanup procedure.

Y - Sample extract treated with an acid cleanup procedure.

Z -

ND - Not Detected at PQL
MRL - Method Reporting Limit
PQL - Practical Quantitation Limit
RPD - Relative Percent Difference

CCI Analytical Laboratories, Inc.
8620 Holly Drive
Everett, WA 98208
Phone (425) 356-2600
(206) 292-9059 Seattle
(425) 356-2626 Fax

Chain Of Custody/ Laboratory Analysis Request

CCI Job# (Laboratory Use Only)

04-026

Date 4-3-03 Page 1 Of 1

PROJECT ID: 21-1-09869-001
REPORT TO COMPANY: Shannon & Wilson
PROJECT MANAGER: Scott Gaulke
ADDRESS: 400 N 34th St Suite 100
Seattle, WA 98103
PHONE: (206) 695-6893 FAX: (206) 695-6777
INVOICE TO COMPANY:
ATTENTION: Same as above
ADDRESS:
P.O. NUMBER CCI QUOTE:

ANALYSIS REQUESTED / OTHER (Specify)

	SAMPLE I.D.	DATE	TIME	TYPE	LAB#	NWTPH-GX	BTEX	NWTPH-DX	NWTPH-HCID	EPA 8021 ☐ 602 ☐	EPA 8010 ☐ 601 ☐	EPA 8260 ☐ 624 ☐	EPA 8270 ☐ 625 ☐	EPA 8081/8082 ☐ 608 ☐ PCB only ☐ Pest only ☐	Metals Priority Pollutant ☐ RCRA ☐ TAL ☐	Metals Other (Specify)	TCLP-Metals ☐ VOA ☐ Semi-Vol ☐ Pest ☐ Herbs ☐										DRY WEIGHT	NUMBER OF CONTAINERS	RECEIVED IN GOOD CONDITION?
1.	B8-7B, S-1	4/3							X																	X		
2.																												
3.																												
4.																												
5.																												
6.																												
7.																												
8.																												
9.																												
10.																												

SPECIAL INSTRUCTIONS

SIGNATURES (Name, Company, Date, Time):

1. Relinquished By: Xiaohui Liu
   Received By: MV OSE 4/3/03 3:42
2. Relinquished By:
   Received By:

TURNAROUND REQUESTED in Business Days*

Organic, Metals & Inorganic Analysis
10 (Standard) 5 3 2 1 SAME DAY

Fuels & Hydrocarbon Analysis
5 (Standard) 3 1 SAME DAY

OTHER:
Specify:

* Turnaround request less than standard may incur Rush Charges

ATTACHMENT F

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL ENVIRONMENTAL REPORT

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL REPORT

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include: the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used: (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors which were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the
ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland